MICROBIAL AND PHYSICO-CHEMICAL DYNAMISM WITH EUTROPHICATION OF PANI KI DHARAMSHALA RESERVOIR JHANSI (U.P.)

THESIS
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SUPERVISOR'S CERTIFICATE

I hereby certify that this thesis entitled **"MICROBIAL AND PHYSICO-CHEMICAL DYNAMISM WITH EUTROPHICATION OF PANI KI DHARAMSHALA RESERVOIR. JHANSI. U.P."** is an original piece of research work carried out by Manisha Agrawal Deshmukh under my guidance and supervision for more than 3 academic years and also carried lab work for more than 200 days for the degree of Doctor of Philosophy of Bundelkhand University Jhansi. (U.P.) She fulfills all the requirement laid under the clauses of Phd. Ordinance. Bundelkhand University Jhansi.

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SECTION-1 CHAPTER -A

INTRODUCTION

Water is an important component of Ecosystem being the root of all living creatures. Water occurs naturally in different water bodies-oceans, seas and lakes etc. water in seas and oceans comprise 97% and remaining 3% is in freshwater systems, out of which three fourth is in immobilised form in glaciers and ice caps. Major part of remaining ¼ freshwater is ground water while ponds, lakes and rivers accounts only for 0.33% of this freshwater. The main source of water in India is in rivers, assessed at 1,645 thousand million m^3 (1,645 billion m^3), while ground water accounts for 255 billion m^3. Thus the total water available from all sources in India is about 1,900 billion m^3 (Rao 1975).

In India maximum water in rivers, lakes and ponds occur during the 4 monsoon months, for the remaining part of the year we have to depend on water resources stored during the monsoon season. Therefore, conservation in form of storage is essential. Now a days emphasis has been laid on new water harvesting techniques. (C.S.E reports).

The increasing anthropogenic influences in recent years in and around aquatic systems and their catchment areas have contributed to a large extent towards deterioration of water quality and dwindling of water bodies commonly leading to rapid Eutrophication.

Due to growth in population and rapid industrialization the ground water has also started exhausting hence the water in lakes streams or reservoirs must be properly harnessed. Due to indiscriminate use and human activity, these water resources are being highly polluted. Though many

NGO's and scientific organisations (C.S.E. and Limnological Research Centre) have started working towards conservation but there is still need to create awareness of the facts amongst the common masses.

Usually with the run off from the catchment areas the water bodies accumulate nutrients washed off from the top soil. The gradual increase of nutrients in water bodies makes it suitable for growth of phytoplanktons and at times macrophytes. As also noticed during the present study. This is natural eutrophication. Human activity through waste and faulty agricultural practices, industries, temples and household washouts etc. further overload the organic and inorganic matter into the water bodies which may sometimes cause an accelerated productivity in the water bodies.

Primarily algal content increases in the water and subsequent death of algal blooms leads to consumption of oxygen dissolved in water; creating hypoxic and at times anoxic situation. "This excess eutrophication can kill the fish, cause odour and increase pathogenic microbes and fauna." (N.K. Kaushik-Down to Earth – June 2001).

Algae is also involved in water pollution in number of significant ways. Algal blooms deteriorate the water quality and affect its use. The selective type of algae existing in polluted water are also being used as indicators of pollution.

Prevention of Eutrophication in reservoirs and lakes is the need of time to maintain water quality. The two substances considered most significant in this growth stimulation are nitrogenous compounds and phosphates. These together with CO_2 are generally the materials whose availability determines the quality of algal growth.

As Eutrophication proceeds the algae which tend to become prominent in addition to bloom formers may be planktonic, floating or periphytic. Secondly diatoms which are characteristic of polluted waters, reach their optimum development in eutrophic water bodies.

Sediment is the most widespread pollutant of surface water. The finer fractions of sediment cut down light penetration and thus greatly reduce algal production. Turbidity caused by sediments has deleterious effect on benthic biota and fish. Large amount of sediment settles out annually in slow moving sections of surface water particularly in reservoirs. This causes reduction in the storage capacity of the reservoir.

The complex web of above mentioned factors and other biotic factors along with climate and physicochemical factors continuously operates in natural water system.

Physico-chemical characteristic when changed also bring about indications of pollution. The discharge of domestic wastes through sewage and effluents into natural water reservoir results in Objectionable Conditions.

The selected reservoir (Chaupada according to Bundelkhand Civilisatoin) seems to be under the stress of most of the mentioned conditions. The study was therefore undertaken to evaluate the quality of water in the reservoir in relation to human health and hazard.

THE SELECTED STUDY AREA

JHANSI CITY

In Bundelkhand region's historical record one of the bright spot is the city of Jhansi. It is the city of "Maharani Laxmibai" the key figure in the Mutiny of 1857. Its archeological treasure, political and traditional values have won worldwide acclaim. The Rocky areas and appealing natural surroundings initially inspired the residents to lead a life of hardworking human being.

Jhansi District lies in South-West part of U.P., situated between $25^{0}30'$N – $24^{0}51'$N latitude and $78^{0}40'$ – $79^{0}25'$ longitude. Its altitude is 271 mts above sea level. It comprises rocky areas with undulated topography. The area is covered by Bundelkhand granite. Topographically Jhansi district can be divided into two regions – one that of plains which is suitable for agriculture and second is mountainous comprising Vindhya mountains and many small mountains. Three main rivers are Betwa, Dhasan, and Pahuj.

Jhansi being rocky terrain, there has been shortage of water, specially for irrigation purpose. To compensate this short supply some reservoirs were built and occasionally natural lakes were given some attention.

In Jhansi region during ancient times centrally located Pani Ki Dharamshala and Gopalji Ki Bagiya Reservoir were constructed along with many small tanks locally called 'Bawadi'.

Jhansi city still faces an acute scarcity of water mainly because of low and erratic rainfall, high run off and rocky terrain with low infilteration capacity. During last few years demand for domestic water supply has

increased tremendously mainly due to growth in population, advanced agricultural practices and rapid proliferation of industrialization.

The three main reservoirs in Jhansi city are :

[A] Laxmi Tal

It is situated at the outskirts of Laxmi gate (one of the gate situated on the ancient walls within which Jhansi city was confined). Adjacent to it is the famous Kali Temple. A portion of this is used for farming of water chestnuts and for irrigating gardens, farms etc. situated along the banks. It is also a washing embankment for washermen. Its excess water is flown out to Garhmau tank approximately 12kms from Laxmi tal.

[B] Antia Tal

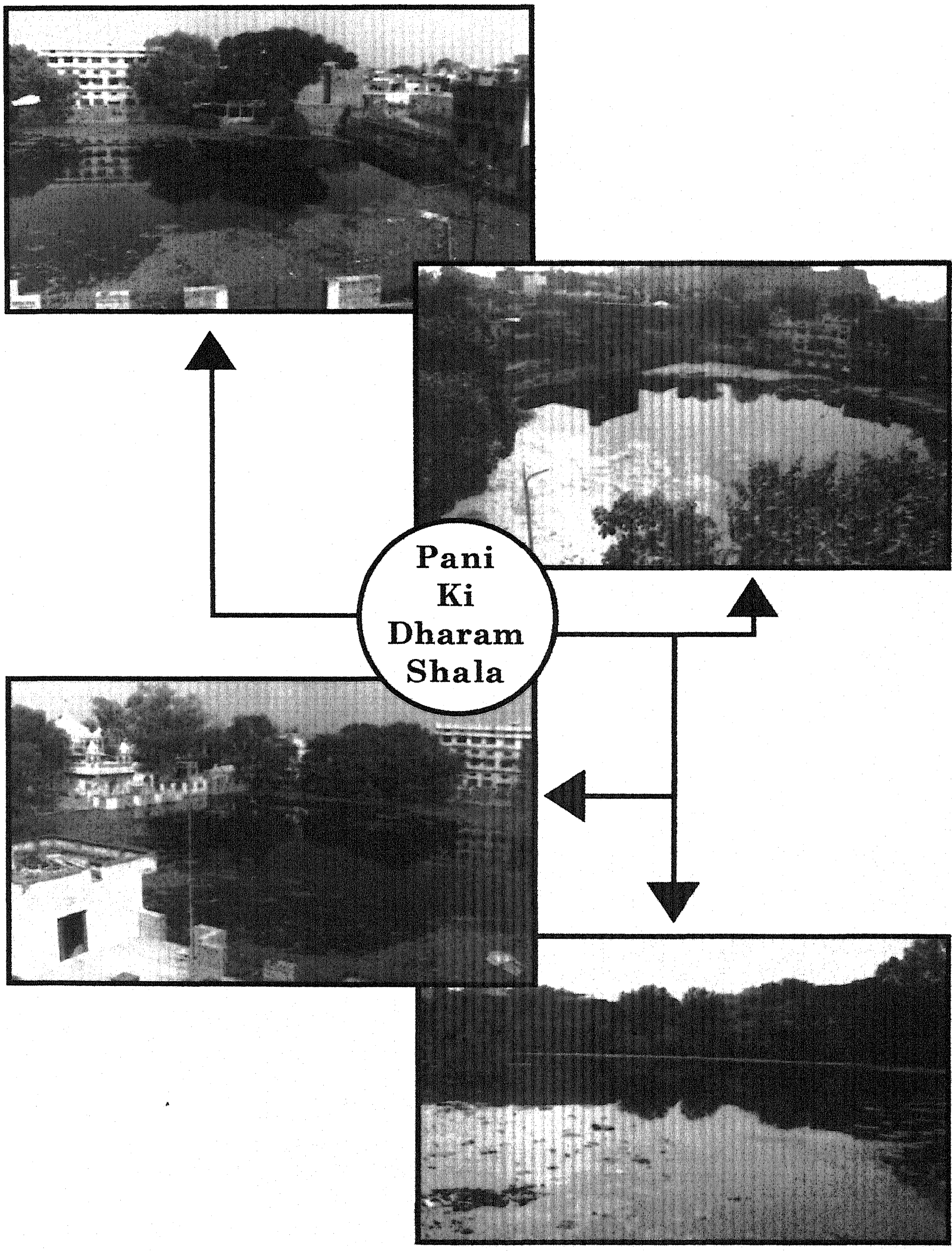
A famous historic pond, constructed in ancient era for use of bathing elephants of the royal kingdom, hence the name Antia Tal. It was later on used for farming of water chestnuts. Today its condition is miserable with little water depth left and no farming is done. Most of its part has succumbed to the pressures of encroachment for residential complexes. Remaining part is full of water hycinth Eichornia. The outlet runs towards Mehndi Bagh where excess water irrigates the plants present in the area.

[C] Pani ki Dharamshala

This is situated in the heart of city and is surrounding by temples, schools and densely populated area. Initially its water was used by local residents for bathing and washing clothes. It has self replenishing water

PLATE-1

Views of Reservoir From Different Angles.



Reservoir condition 3 months before the begining of the study period.

source. One main sewer line and many small sewage water channels open in it. It is in hazardous condition thus selected for study.

THE RESERVOIR SELECTED FOR STUDY

'PANI KI DHARAMSHALA'

The reservoir is quite age old and indicates towards ancient water harvesting technique where water was collected by constructing wall around the ground water source resembling the Naula or Hauzi of Uttarakhand (Citizen's Report 'Dying wisdom' 1997 Edition. Council for Science and Environment). In Bundelkhand these are termed as 'Chaupadas'.

It is situated in the densely populated area of the city and is surrounded by temples on all four sides. The reservoir has constructed boundary with 7 steps, which being submerged in water are not visible. It is always filled with water as it has self replinishing source of ground water within it.

Initially this reservoir was used by people for taking holy dip before entering the temple to perform pooja. Later local residents used it for bathing and washing clothes. Sometimes it was also used as swimming training centre. But today it remains totally neglected.

The area of reservoir is 75ft by 100ft. According to unconfirmed sources initially the depth was considered to be 30ft with water spread area 5625ft and water holding capacity of 4695.72 cusec. Though due to excessive organic matter dumping, water depth varies from 10 to 20ft at individual sites.

Now a days heavy loads of floral wastes from temples and house hold waste bags are being dumped in it. Surface accumulation of organic matter is

very high with waste material entangled in the network of surface creaper, an aquatic macrophyte Ipomoea sps. Certain land plants have started appearing over the accumulated organic matter. From the southern end one main drainage enters the reservoir this drainage is the diversion of another sewer line which passes through this reservoir. Due to such contaminated conditions today it has lost its use. Thus during an era of water scarcity such a waste of water resource, which could have been effectively brought into use. Its management is essential specially in view of restoration of water table for neighbouring wells and hand pumps.

The points or stations for sampling were selected keeping in mind the position of underground sources, temples and school building. Accordingly the following sampling sites were selected.

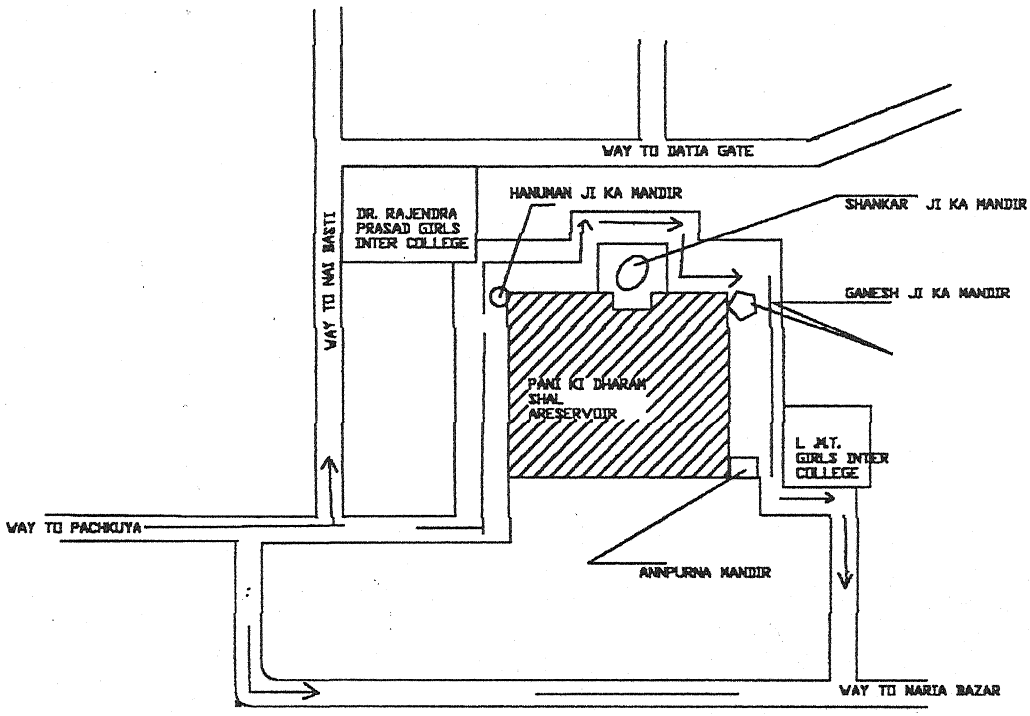
SITE A – Near Hanuman Temple (South-West End) Rajendra Prasad Girls High School and Jain Nursing home lies opposite to this site.

SITE B – Diagonally opposite to site A (North-East End) Near Annapurna Temple. Another school 'Lokmanya Tilak School' lies close by, drainage crosses through this site.

SITE C – (West End) Main temple adjacent to this site is – Shankarji's Temple.

From each site, water samples of two depths were collected at fortnight intervals one just below the surface and other at 5ft depth.

Fig.1 Key Plan of **'Pani ki Dharamshala'** indicating the sites.



KEY PLAN OF PANI KI DHARAM SHALA

The study undertaken to evaluate the water quality in the reservoir covered different physico-chemical parameter and microbial study.

The colour of water was determined scientifically by its optical characteristics. It is influenced by selective transmission of light, the suspended matter, discharge of effluents and also due to reflection of scattered light at the surface of finely suspended mineral particles. The presence of plankton and organic matter also impart certain colour.

Temperature is the measure of intensity of heat stored in a volume of water. It was correlated with atmospheric temperature morphometric features and biological activities. It is basically an important factor as it affects chemical phenomenon. It has been studied in detail by Shivkumar et al 1989; Nalin K. Shastri et al 1991; Gupta and Malhotra, 1991.

Conductivity is the measure of capacity of substances or solutions to conduct electric flow. It gives an idea of dissolved salts present in waterbody. Seasonal variation causes fluctuation in concentration of dissolved salts in water. It was observed that the concentration increased due to evaporation and dilution due to precipitation decreases its concentration. It is claimed that richer the water body in electrolytes, the greater is its biological productivity.

The effect of electrical conductivity on phytoplankton was studied by Trivedi et al 1985; Nalin. K. Shastri et al 1991 & Mishra and Saxena 1991. High conductivity reflects pollution status as well as trophic levels of aquatic body. However pure water is a poor conductor of electricity. Conductivity is reciprocal of resistance.

pH is the scale of intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. Alteration in pH is brought about by changes in other physico-chemical parameters. The changes in carbondioxide content, hardness, photosynthetic activity etc causes the change in pH. Fluctuation of pH may be due to changes in the above mentioned criteria at different sampling sites as well as in different seasons. pH of natural water varies around 7, generally over 7 (i.e. alkaline) due to the presence of sufficient amount of carbonates. pH of water also gives an idea of the type and intensity of pollution. Saxena et al 1966 found pH of Ganga river as 8; Palhariya and Malviya 1988 recorded 11.5 in Narmada river.

Chloride is one of the important inorganic anions in natural water and waste water. Natural inland waters generally have low chloride ion concentration. In natural freshwater high concentration of chlorides is considered as an indication of pollution due to organic wastes of animal origin (Thresh 1944; M.M. Saxena 1990). Goel et al 1980 and D.N. Saxena, 1991 found that chloride contents increased with degree of eutrophication.

Carbon-dioxide dissolved in water is the source of carbon that can be used in photosynthetic activity of aquatic autotrophs. Sources of carbon-dioxide in water are precipitation, diffusion from atmosphere to surface water, infiltration through soil and metabolic activity of organisms of water. Many workers studied various physico-chemical parameters and observed inverse relationship between carbon-dioxide and dissolved oxygen- Saha et al 1971; Mandal and Hakim 1975.

Dissolved oxygen is an important parameter of water quality and is an index of physical and biological processes going on in water. It is essential for

metabolic processes of all aerobic organisms and affects the solubility and availability of many nutrients which in turn affects the productivity of aquatic ecosystem. Palmer 1980; Nalin K. Shastri et al 1991 observed that dissolved oxygen affects aquatic and microbial population. Main source of oxygen are diffusion from air and photosynthetic activity within the water bodies. Respiration of organisms, decomposition and mineralisation also affects the oxygen balance.

Biochemical oxygen demand is amount of oxygen required for biochemical degradation of organic materials and is used as an index of organic pollution in water. It varies with seasons of the year, total dissolved solids as well as quantitative value of microbial population. Zutshi & Vass 1982; Nalin K. Shastri 1991 found low value of BOD in colder months due to low quantity of total solids and low quantitative number of microbial population.

Phytoplankton study and microbial study of water has great significance. The planktonic population may comprise of single species or combination of species. These species may be present in some months or may persist throughout the year. The periodicity of microbial population varies from season to season. Physico-chemical condition during day and night time also determines the population at different depths.

Generally the diatomic forms, blue green algae and green algae dominate the flora of aquatic body as they show high tolerance level to meteorological conditions and physico-chemical factors. Chakravarty et al 1997 found direct correlation between abiotic factors and planktonic population. The inter relation between algal density, periodicity and

environmental conditions along with bacterial study have been carried out during the period of study.

Emphasis on total coliform count is usually worked out in fresh water study as it is the commonly used indicator of sewage pollution and Eutrophication. Bagde & Verma 1991 studied on interaction between coliform bacteria and physico-chemical parameters. The present reservoir showed high coliform count indicating towards the possible public hazard.

In India work on hydrobiology had been done by many workers. Iyengar 1940; Ganpati 1943; Zafar 1967.

Ganpati, 1955 have done hydro-biological investigations of Stanley reservoir & river cauvery; Zutshi et al 1980 conducted comparative limnology of nine lakes of Jammu and Kashmir; U.S Bagde and A.K. Verma 1985 worked on the limnological studies of JNU Lake New Delhi; Tiwari et al 1986 worked on water quality parameters of Meerut District,; Parminder Kaur and N.K. Mehra 1992 has done evaluation of water quality of river Yamuna. The list of workers does not end here.

These works are conducted on large reservoir and give the position of that region. So far no work of any significance has been done on Pani Ki Dharamshala reservoir, which is located in a populated area and dumped with unusable sewage water of surrounding population. If such indiscriminate practice continues it may soon turn into a public hazard. In view of this and above studies the present work has been planned in the following lines :

SECTION 1 : METEOROLOGICAL RECORDS

This section deals with general climate of Jhansi and meteorological records during the study period, based on data obtained from IGFRI Jhansi.

SECTION 2 : MATERIALS AND METHODS

This section includes various materials and methods used for collection and analysis of water samples collected from various sampling stations.

SECTION 3 : REVIEW OF LITERATURE

This section includes information about available literature on subject and literature used for the study and identification of organisms.

SECTION 4 : PHYSICO – CHEMICAL STUDY

This section deals with the parameters undertaken for physico-chemical studies. During the present studies following parameters were selected – water colour; temperature; pH, electrical conductivity, chloride content; dissolved oxygen, BOD, carbonate and bicarbonate content, free carbon dioxide, calcium and magnesium content. Investigations on these parameters were done fortnightly at each sampling station for entire study period of one year. After this study datas for these parameters were investigated on each sampling stations at 4 hours intervals for 24 hours.

SECTION 5 : QUANTITATIVE AND QUALITATIVE DYNAMISM OF PLANKTONIC POPULATION

In this section quantitative and qualitative estimation of phytoplanktons and zooplanktons collected, has been tabulated.

Primary productivity of water has been analysed by gas exchange method.

SECTION 6 : QUANTITATIVE & QUALITATIVE ANALYSIS OF MICROBIAL POPULATION.

This section deals with study made fortnightly on qualitative and quantitative analysis of microbial population with emphasis on E. coli and MPN count of coliform. Standard plate count for quantitative study was also done. Sampling for specific pathogens was occasionally done i.e. E. Coli, S. typhyae, V. cholerae, Streptococcus faecalis.

SECTION 7 : CONTROL MEASURE

Deals with attempts made to control the number of organisms, keeping in view the prescribed water standards.

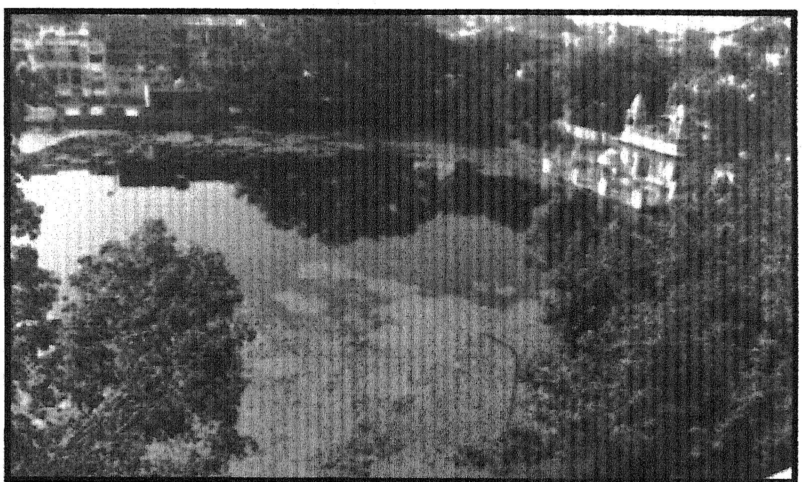
SECTION 8 : DISCUSSION AND CONCLUSION

The observations made during the study period have been correlated and discussed in this section considering abiotic and biotic components and seasonal variation. Observation of present workers is also correlated with those of others.

SECTION 9 : GENERAL SUMMARY

SECTION 10 : BIBLIOGRAPHY

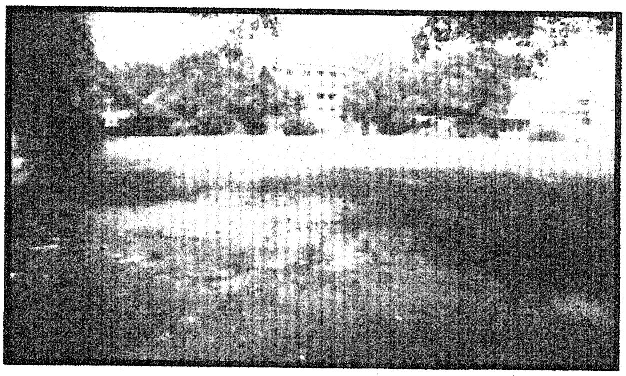
PLATE-2



Advent of algal components also in view are the waste materials thrown in it (Oct. 99)

PLATE-3

Development of Angiospermic Flora.



View :- Shot from Hanuman Temple (Near Site - A)

View :- Taken from Annapurna Temple (Near Site - B)

View :- Taken from Shanker Temple (Near Site - C)

CHAPTER B

METEOROLOGICAL RECORDS

Jhansi faces extremes of climatic conditions. It is very hot during summer months (reaching maximum temperature sometimes even to 47.8^{0}) and extremely cold during the winters (minimum temperature sometimes reaching 3^{0}C). Climate of Jhansi can be distinctly divided into 3 seasons – Rainy, Winter and Summer seasons, each season usually extending to a period of 4 months.

The **Summer Season** begins from mid February and ends in mid June. During this season the temperature soars high and is often accompanied by frequent dust laden hot winds locally termed as 'Loo'. The days are hot while nights are cool. Jhansi is one of the hottest place in Uttar Pradesh.

The **Winter Season** starts from mid October and ends in mid February. Though during the study period low temperature is periodically short in comparison to high temperature period (Table –I). The temperature becomes extremely low. December and January are the coldest months.

In this region the **Monsoon Season** starts from mid June as the South West monsoon winds generally start from 3rd week of June and continue till September end. The maximum rainfall is during the month of July.

Due to irregular rainfall, extremes of temperature, slopy and ravinous area the problem of soil conservation persists. There is heavy drainage and erosion during rains.

The climate conditions of Jhansi city have been described by Shankar Narayan Dabadhghao (1970). Alka Sethi (1991). Yearly bulletins of District Development Authority Jhansi published by District Information Office.

The present meteorological data's were obtained from meteorological department of IGFRI, Jhansi. The monthly climatic variation for the study period from October 1999 to September 2000 are presented in Table – I.

CLIMATIC CONDITIONS DURING THE STUDY PERIOD

1. ATMOSPHERIC TEMPERATURE

There is seasonal variation in atmospheric temperature. With the onset of winter season there is gradual fall in temperature which begins from November 1999 (18.9^{0}C) reaching th average minimum temperature during December 1999 and January 2000 (15.5^{0}C). The maximum temperature was observed during the hottest month of summer season, May 2000 33.05^{0}C being the average temperature, while maximum temperature in May was 40.1^{0}C and minimum 26.0^{0}C. Temperature started declining by the end of June 2000 (28.8^{0}C) as the monsoon season begins from June.

2. Relative Humidity : The average relative humidity varied from 40% to 79%.

Minimum value of 40% was recorded in the month of April 2000 and maximum value was recorded in August 2000 – 79%. In the year 2000 there was gradual rise in Relative Humidity percentage from May till August 2000.

3. **Total Rainfall :** Minimum amount of rainfall recorded was 'O'mm in the months – November 1999, December 1999, January 2000 to March 2000. Maximum rainfall recorded was 348.1mm during July 2000. The total annual rainfall during the study period was recorded to the 729.3mm.

4. **Total Number of Rainy Days :** During the study period 6 months showed dry period as minimum number of rainy days observed were 'zero' from November 1999 to April 2000.

   The month which recorded maximum number of rainy days was July 2000 (11 rainy days). Total number of rainy days throughout the study period were – 39 days.

5. **Wind Velocity :** Generally light winds were observed for most of the period, strengthening in the summer months. Minimum wind velocity was during the months of October 1999, November 1999 and December 1999. Its value ranged from 0.4 to 0.5 km/hr. Maximum wind velocity was 7.9 km/hr during May 2000.

6. **Bright Sunshine :** The datas of bright sunshine show that brightest sunshine hours/day fall in the month of March 2000, 9.9hrs/day. While the least sunshine was observed in the month of July 2000-3.8hrs./day.

7. **Evaporation :** The minimum evaporation recorded was 1.6mm per day in December 1999 and maximum evaporation was recorded to be 10.1mm/day in May.

According to ecological studies on grassland of Jhansi; Ann. of Arid Zone, 1970, 9:54-70, Jhansi city is covered by red and black soils. Black and Red soil in the same areas merge into one another. Black soil is rich

in potash, iron, lime, aluminium, calcium carbonate and magnesium carbonate. Black soil is highly clayed and has high moisture retention capacity. Red soil covering some areas of Jhansi include Red loam, yellow earths etc. soil of this group are believed to be of sedimentary formation derived from crystalline metamorphic rocks. Red soil is generally characterized by light texture with porous structure, absence of lime, free carbonate ions and presence of soluble salt in small quantity (0.5%).

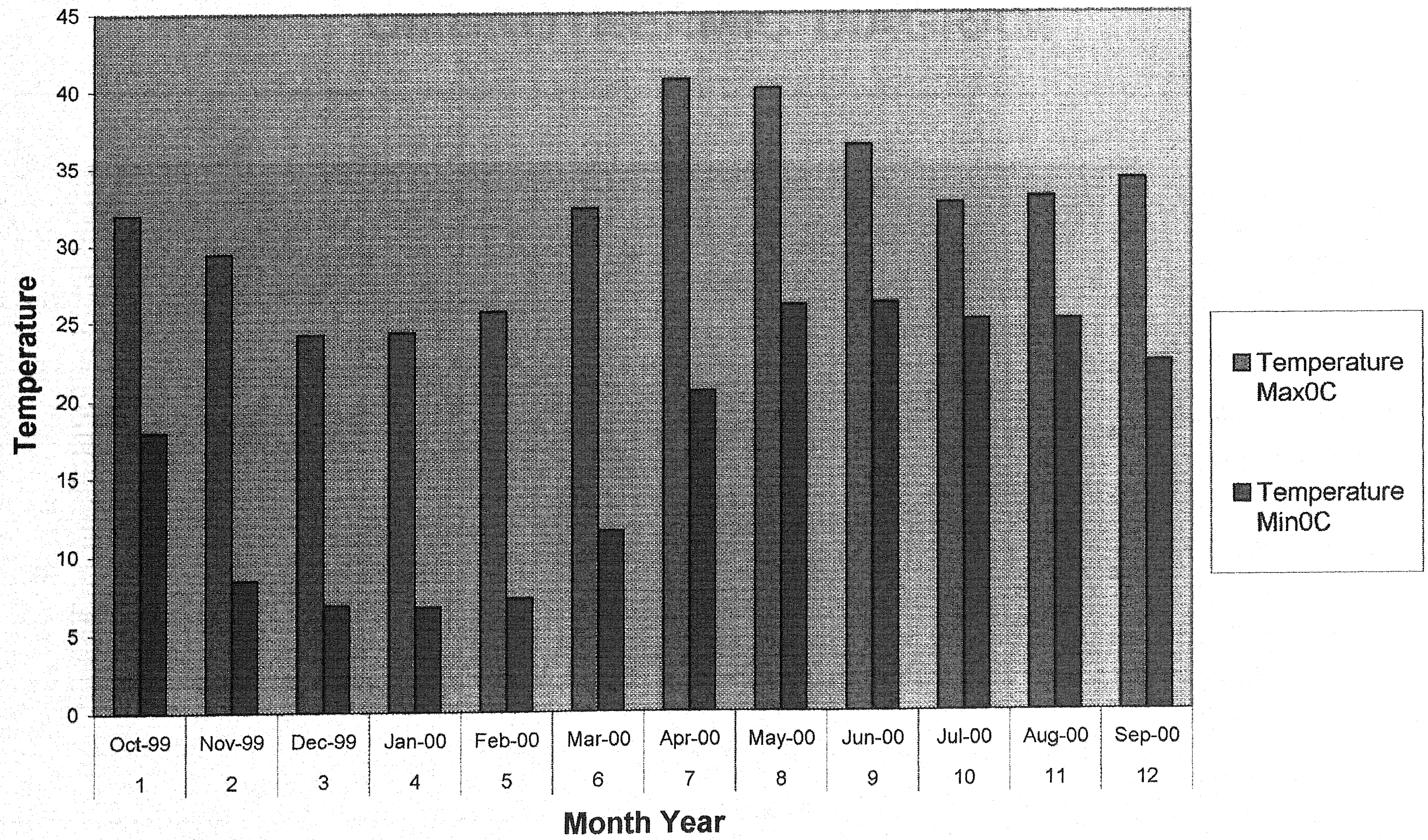
The effectiveness of climatic factors like temperature precipitation and length of the day period can be understood in a better way by means of ombrothermic diagram. Fig. 2. In this the thermic curve (average monthly values of temperature) and the rainfall values are drawn together. In order to bring out the length of the dry period on the graph, the scale of rainfalls is taken as double to that of temperature. A month is considered dry when its rainfall is less than twice its average temperature (T) : $P < 2T$.

TABLE-I

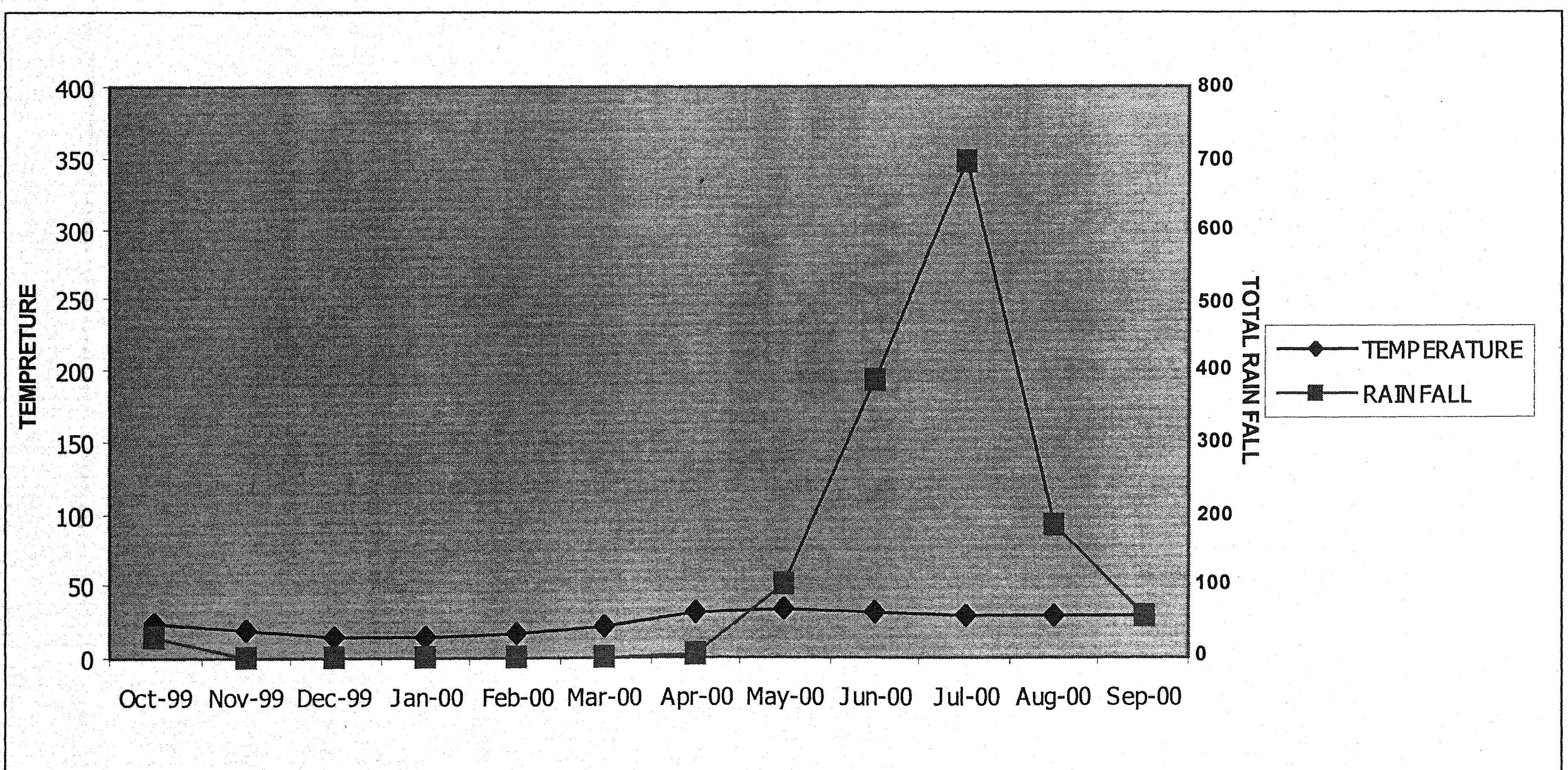
MONTHLY VARIATION OF METEOROLOGICAL RECORD DURING STUDY PERIOD OCTOBER 1999 TO SEPTEMBER 2000

Sr.No	Month & Year	Temperature			Relative humidity Aver %	Total Rainfall (mm)	Number of Rainy Days	Wind Velocity (Km/Hr	Sunshine Hrs/Day	Evaporation (mm/Day)
		Max ^{0}C	Min ^{0}C	Aver ^{0}C						
1	Oct-99	31.9	17.9	24.9	67	15.6	2	0.4	8.2	2.9
2	Nov-99	29.4	8.4	18.9	60	0	0	0.4	8.5	2.5
3	Dec-99	24.2	6.8	15.5	66	0	0	0.5	7.4	1.6
4	Jan-00	24.3	6.7	15.5	64.5	0	0	1.7	8.4	2.1
5	Feb-00	25.6	7.2	16.4	63.5	0	0	2	9.2	3.2
6	Mar-00	32.3	11.5	21.9	56.5	0	0	2.9	9.9	5.8
7	Apr-00	40.7	20.5	31.1	40	1.5	0	4.5	9.7	9.3
8	May-00	40.1	26	33.05	54	50.3	6	7.9	8.7	10.1
9	Jun-00	36.4	26.1	31.25	66	193.1	6	6	6.2	5.6
10	Jul-00	32.6	25	28.8	78.5	348.1	11	4.4	3.8	3.3
11	Aug-00	33	25	29	79	90.8	10	2.3	5.5	3.5
12	Sep-00	34.1	22.3	28.2	70.5	29.9	4	2.7	6.9	4.3

Fig 1- Monthly Variation In ATM. Temperature During Study Period



OMBROTHERMIC DIAGRAM



SECTION - 2

✦

MATERIALS
AND
METHODS.

SECTION-2
MATERIALS AND METHODS

Water samples from the 'Pani ki Dharamshala' reservoir were collected at fortnightly intervals for the period of one year from October 1999 to September 2000. The samples were collected from 3 sampling stations – A, B, C, at 8:30 – 9am from two levels one (A_1, B_1, C_1) from the sub surface level approximately 10 – 15 cms below surface and second from the depth of about 5ft (A_2, B_2, C_2). The samples were taken by lowering the Ruttner sampler. The stopper of the glass bottle of the sampler was opened and closed when the sampler is lowered at the required depth with the help of movable string.

The samples thus collected were analysed in the laboratory within 6 hrs. of collection.

The physicochemical parameters were analysed according to the methods described by H.L. Golterman et al (1978); Greenberg et al (1995, 1998); Adoni et al (1985); APHA (1985) M.M. Saxena (1990). Temperature and pH were determined in the field with the help of sensitive thermometer and BDH range pH strips respectively. pH and conductivity were analysed in the laboratory by pH meter and conductivity meter respectively. Chloride content, Free carbon dioxide, dissolved oxygen, total hardness, total alkalinity, bicarbonate alkalinity and calcium content were all analysed by 'Volumetric Titration Methods' in lab.

DETAILS OF METHODS OF ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS

1. **Colour :** Observation for colour of water made visually.

   The water samples were taken in the test tubes and were centrifuged to remove the suspended matter and then observed.

2. **Temperature :** Temperature was recorded at site for two levels of water by using sensitive thermometer.

   Readings were taken at 8:30am to 9am as soon as the samples were taken.

3. **pH (Hydrogen Ion Concentration) :** pH was determined in the field by BDH narrow range pH indicator paper strips. The pH was also determined in the laboratory with the help of systronic pH meter type 335.

4. **Conductivity :** Electrical conductivity of the water samples was determined in laboratory with the help of systronic conductivity meter, expressed in micro mhos. It is good and rapid measure of total dissolved solids. This method for determining total dissolved solids was suggested by Welch (1948), Adoni et al (1985) APHA (1985).

   Calculation –

   $$\text{Conductivity at } 25^0\text{ C Micro mho's /cm} = \text{Observed conductance} \times \text{Cell constant} \times \text{Temp. Factor}$$

   Cell constant = 1.168 or as per model given in manual.

   Temp factor at 25^0C noted from Table. (Golterman et al 1978)

5. **Chloride Contents :** The estimation of chloride content was carried out according to Argentometric Method (APHA, 1985, Trivedy and Goel

1986, Greenberg et al 1995, 1998; M.M. Saxena 1990). It resembles the Mohr's Method.

The procedure includes Titration of sample by silver nitrate using potassium chromate as an indicator.

Suitable portion of sample (100ml) was taken in titration flask and kept over white paper, 1ml potassium chromate indicator was added, this gives transparent yellow colour to the sample which was then titrated with standard silver nitrate solution (0.0141 N) till the colour changed from pure yellow to pinkish yellow end point. (first the clear solution changes to milky yellow and then each drop added brings brick red colouration, with constant stirring initially the brick red colour disappears gradually the solution gets pinkish yellow colouration as end point which stays for long).

The reagent blank value was determined by titrating the distilled water in the same way.

The formula used for calculating the chloride contents is as follows :

$$\text{Chloride content mg/L} = \frac{\text{ml titrant used for sample} - (\text{ml titrant used for blank})}{S} \times N \times 35.450 \times 1000$$

S = ml sample used for titration

N = Normality of titrant = 0.0141 M

6. Dissolved Oxygen : Dissolved oxygen is a very important parameter of water quality. Two main sources of dissolved oxygen in water are :

(i) Diffusion of oxygen from air

(ii) Photosynthetic activity within water

Winkler (1888) propounded the technique of estimation of dissolved oxygen in water which is followed even today and is termed as Winkler's Method (given by Adoni 1985, M.M. Saxena 1990). Winkler's Method has later been slightly modified as Azide Method (Greenberg 1998) since Alkaline Iodide Azide solution is used.

Samples were collected in glass stoppered BOD bottles of known volume (250ml).The samples were immediately fixed by careful addition of 2 ml each of Manganous sulphate and Potassium Iodide Azide solutions. Separate two ml pipettes were used for this purpose. The stopper was placed back and bottles were shaken. Brown precipitate was then formed. (Samples at this stage can be stored for few days if immediate titration could not be done). 2ml of conc. Sulphuric acid was added and sample solution shaken to dissolve the precipitate. (Straw coloured clear solution formed). 100ml of the above sample solution was gently transferred in the conical flask for titration & placed on white paper. The sample was then titrated by 0.025 N sodium thiosulphate solution drop by drop until the solution turned pale yellow. At this stage few drops of starch indicator solution were added and further addition of titrant is carried by dropwise titration. When the bluish balck colouration imparted by reaction of starch and iodide turns to colourless, the end point reading was noted.

As fraction of contents were used for titration the dissolved oxygen was determined using the following formula :

$$DO\ mg/l = \frac{V_1 \times N \times 8 \times 1000}{V_4 \left(\frac{V_2 - V_3}{V_2} \right)}$$

V_1 = Volume of titrant used

V_2 = Volume of sampling bottle

V_3 = Vol of $MnSO_4$+Vol. of KI solution

V_4 = Volume of fraction of sample used for titration

N = Normality of titrant (0.025N sodium thiosulphate)

7. **Biochemical Oxygen Demand (BOD) :** The consumption of oxygen by micro-organisms in aerobic degradation of the dissolved or even particulate organic matter is called BOD. (M.M. Saxena 1990).

BOD was evaluated by measuring oxygen concentration in sample before and after incubation in the dark at 20^0 C for 5 days (or 27^0C for 3 days). Preliminary dilution and aeration of samples is usually necessary to ensure that not all oxygen is consumed during incubation.

For dilution of sample, when necessary, BOD free dilution water is prepared. To this water following solutions were added at rate of 1ml each solution per litre – phospate buffer solution, magnesium sulphate, calcium chloride solution and ferric chloride solution. The dilution of the sample is done at the rate given in the Table by M.M Saxena 1990.

Samples were collected in twelve BOD bottles (2 sets of 6 bottles each). 1 ml of allylthiourea was added to each bottle.

In one set of bottles the dissolved oxygen was determined immediately following the modified Winkler's Method. The other set was incubated at

27^0 for 3 days in BOD incubator. After 3 days of incubation of oxygen concentration of these samples were estimated by same method as described above.

BOD was estimated by the following formula :

BOD (mg/l) $=(D_1 - D_3) \times$ Dil factor

If not diluted BOD $= D_1 \times D_3$

D_1 = Initial dissolved oxygen in sample.

D_3 = Dissolved oxygen after incubation for 3 days.

8. **Free Carbon Dioxide :** Free carbon dioxide was determined by titration method. In the titration flask 50ml of sample was taken and 2 – 3 drops of phenolpthalein indicator was added. In case the colour changed to pink, free carbon dioxide would be absent. As the samples remained colourless, presence of free CO_2 was indicated.

The colourless solution was then titrated with sodium hydroxide solution (0.2272N) until pink colour appeared (end point).

Formula used for calculation :

$$\text{Free } CO_2 \text{ mg/l} = \frac{Vt \times 1000}{Vs}$$

Vt = Vol. of titrant used.

Vs = Vol. of sample used.

9. Alkalinity :

(A) Carbonate Content :

Presence of carbonate or Bicarbonate content was determined by titration method as according to Adoni et al 1985, M.M Saxena 1990.

After collection of samples 50ml of the sample was taken in conical flask and 2-3 drops of phenoplthalein indicator was added. If water sample turned pink, presence of carbonate or hydroxide is indicated. It is then titrated with 0.02N sulphuric acid till pink colour disappears. The end point is noted as P. Non appearance of pink colour indicates absence of phenolpthalene alkalinity.

As per analytic methods of M.M. Saxena (1990) if P (Phenolpthalein alkalinity is 'ö' then hydroxide and carbonates are said to be = 0. and bicarbonate alkalinity is supposed to be equal to T. (Total alkalinity).

(B) Total Alkalinity

For test of total alkalinity, in the above sample add 2 - 3 drops of methyl orange, yellow colour appears. This is titrated with 0.02N sulphuric acid until the colour changed to orange. The reading was noted as 'T' and total alkalinity is calculated as –

$$T = \frac{t \times 1000}{S}$$

T = Vol. of titrant used.

S = Vol. of sample used.

(C) Bicarbonate :

According to Adoni (1985) and M.M. Saxena (1990) if P = 0 then bicarbonate alkalinity = T. titration method is same as above.

To the sample methyl orange indicator is added and titrated against 0.025N sulphuric acid until yellow colour changes to orange. Bicarbonate alkalinity is calculated as T.

$$T = \frac{t \times 1000}{S}$$

To compute the concentration of bicarbonate ions following calculation was employed (M.M Saxena 1990).

HCo_3 – (mg/L) = Bicrabonate Alkalinity x 1.22

10. Calcium Content :

Calcium content was evaluated by EDTA Titrimetric method (Greenberg 1995, 1998; M.M. Saxena 1990).

50ml of sample was taken in Erlynmeyer flask. 1 – 2 ml of NaoH solution is added to produce pH 12 – 13. After stirring 0.1 to 0.2 g of Murexide indicator mixture (Ammonium purpurate + Sodium chloride) was added. The colour of the solution becomes pink. It is titrated with 0.01M EDTA (Ethylene Diamine Tetra Acetic Acid) till the pink colour changes to purple (end point).

To determine calcium content following formula is used for calculation

$$Ca\ (mg/l) = \frac{T \times 400.5 \times 1.05}{V}$$

T = Volume of titrant used.

V = Volume of sample used for titration

To determine calcium hardness following formula is used –

$$\text{Calcium hardness as } CaCO_3 \text{ mg/l} = \frac{T \times 1000 \times 1.05}{V}$$

11. Total Hardness :

Total hardness was estimated according to methods described by Adoni et al (1985) Greenberg (1975).

50ml of sample was taken in the titration flask. To this 1ml ammonia buffer solution was added followed by 2 – 3 drops of indicator – Eriochrome black T. Wine red colour was imparted to the sample. The sample solution was then titrated with standard EDTA titrant (0.01M) with continuous stirring until wine red colour finally turned blue. The reading was then noted and total hardness calculated by following formula –

$$\text{Total Hardness (mg/l)} = \frac{T \times 1000}{S}$$

T = ml titrant used.

S = ml sample

12. Magnesium :

It was estimated by calculation (M.M Saxena 1990) using the values obtained for total hardness and calcium hardness.

Magnesium content is calculated as given below –

$$\text{Mg (mg/L)} = (T - C) \times 0.244$$

T = Total hardness

C = Calcium hardness

PLANKTON STUDY

The plankton community is a mixed group of tiny plants and animals floating, drifting or feebly swimming in the water sample. These planktons also form the integral part of food chain.

SAMPLE COLLECTION AND ANALYSIS

The samples for plankton study were collected at fortnightly intervals at 8.30am. samples were taken from 1 to 1½ feet depth from surface by the sampler and 10 litre water was filtered through the conical plankton net of mesh size 60/μm. The net had 50ml tube at the lower end.

The sample thus collected was taken in a glass bottle and Lugols iodine solution was added to it at the rate of 10ml Lugol's solution per litre of sample. (To prepare Lugol's solution 10g potassium iodide was dissolved in 20ml distilled water and 5g of iodine crystals were added followed by 50 ml distilled water & 5gms sodium acetate). Lugol's iodine solution speeds up the rate of sedimentation of phytoplankton, provides them stain and serves as short term preservative (M.M. Saxena, 1990).

The above treated sample was allowed to stand for 24 hrs. The supernatant clear liquid was removed with the pipette, taking care not to disturb the lower concentrated portion.

The remaining concentrated 10-100ml sample was kept for estimation of planktons. Samples were preserved in 5% formalin to which little glycerine was also added.

QUANTITATIVE ESTIMATION OF PLANKTONS

Quantitative estimation of plankton was made with the help of haemocytometer and number were expressed as per litre of sample.

The systematic identification of the phytoplanktons was done with the help of standard works i.e. Fritsch (1935), Smith (1950), Chapman and Adoni (1985).

ESTIMATION OF PRIMARY PRODUCTIVITY

Primary productivity is defined as :

(i) The rate at which radiant energy is stored by photosynthetic & chemosynthetic activity of producer organisms in the form of organic matter which can be used as food.

or

(ii) Rate of increase in biomass of primary producers.

Gross Primary Production (GPP) is total rate of photosynthesis including organic matter used up in respiration during the period of measurement.

The idea of estimating production from the photosynthetic rate of phytoplankton was first presented by Gaarder and Gran (1927).

Phytoplankton productivity was estimated by 'Light and Dark Bottle Method :-

Water samples were collected and distributed in 2 sets of glass bottles. One set of transparent bottles and second set of dark bottles. The bottles were then suspended in the reservoir water. After the period of 24 hrs. the oxygen content of the bottles was determined by Winkler's estimation method. From the difference between the concentration of oxygen, Net productivity was obtained in transparent bottles based on consumption of oxygen by respiration of phytoplanktons and other organisms and through decomposition of debris in water–

$$GPP = \frac{(LB - DB) \times 0.375}{T.}$$

GPP = Gross Primary Productivity (g c/m^3/day)

LB = Oxygen determined in light bottle.

DB= Oxygen determined in Dark bottle.

T. = Time period of Incubation

MICROBIAL EXAMINATION OF WATER

Microbial population of water indicate its quality, contamination, catchment area, storage conditions which ultimately leads towards its potability. Various methods of microbial examination are being used depending upon the purpose of examination. Methods used for microbial analysis during the present study period are being given below :

[A] QUANTITATIVE ESTIMATION OF BACTERIA

Enumeration of bacteria is done by plate count or serial dilution agar plating technique. The 'Plate Count Technique' is one of the most often

used methods. This method is based on the principle that when material containing bacteria is cultured every viable bacterium develops into visible colony on Nutrient Agar medium'. (K.R Aneja 1996). The number of colonies therefore are the same as the number of organisms contained in the sample. This gives the total viable count.

The procedure involves the making of serial dilutions :

The dilution blanks are labelled as 10^{-1}, 10^{-2}, 10^{-3} ....10^{-7}. The initial dilution is prepared by adding 1 ml of sample into 9ml water blank labelled 10^{-1}. The original sample is thus diluted ten times ($1/1+9 = {}^{1}/_{10}$ & is written as 1 : 10 or 10^{-1}). The contents are mixed and from first dilution tube 1 ml is transferred to dilution blank 10^{-2} with fresh sterile pipette. The same procedure is repeated till the original sample has been diluted 10,00,00,00 (10^{-7}) times, every time using a fresh sterile pipette.

From the appropriate dilutions prepared as above, 1 ml or 0.1ml of suspension is transferred to sterile petriplates and the plates are labelled according to dilution factor. Approximately 15ml of Nutrient Agar medium melted and cooled at 45^{0} C was then added to each petri plate containing diluted sample. The contents of the plates were mixed well and allowed to solidify. Later these were incubated in inverted position for 24 to 48 hrs. at 37^{0} C. All the plates were then observed and number of colonies were counted for each dilution Triplicates were run for each dilution.

SPC per ml of sample was calculated by following formula –

SPC /ml = Average no. of colonies x dilution.

[B] COLIFORM TEST INCLUDING MPN

The microbiological quality of water is based on testing for non pathogenic indicator organisms principally the coliform group.

Water contaminated by faecal pollution is identified by presence of coliform bacteria.

Laboratory method used during the present study for detection of coliforms was 'Multiple Tube Fermentation Technique'. Through these tubes MPN count was determined. (K.R Aneja 1996; Mark. J. Hammer 1998). The test is performed sequentially in 3 stages :

Presumptive; confirmed and complete.

EXP. 1 PRESUMPTIVE TEST

In this test known volumes of water (sample) are added to lactose broth fermentation tubes of two concentrations (single strength and double strength) and production of acid and gas from fermentation of lactose is a positive presumptive test for coliform bacteria.

A statistical method is used to estimate the population of coliforms, the result obtained is expressed as most probable number (MPN). A count of number of lactose fermentation tubes showing positive test was taken and MPN was obtained by matching the results with those provided in the statistical table Mc Cardy, APHA 1971).

EXP. 2 CONFIRMED TEST

This test is used to confirm the presence of coliforms in water samples. In this test samples from positive presumptive tubes were streaked onto the

selective differential medium. The medium used was Eosine-Methylene blue (EMB) Agar Lactose fermenting bacteria gives coloured colonies (positive confirmed test), non lactose fermenters produce colourless colonies on EMB Agar. E. Coli colonies exhibited dark centres with metalic sheen.

On Mac Conkey Agar E. Coli produced pink colonies.

EXP. 3 COMPLETE TEST

This is the confirmatory test for the presence of E.coli in water sample. In this test colonies from EMB Agar were isolated and inoculated into a lactose broth tube and streaked on nutrient agar plate to perform gram staining. If there is production of acid and gas in the inoculated lactose broth tube & these are rod shaped bacteria showing gram negative reaction these confirm the presence of E. Coli in the water samples and is considered as positive complete test.

[C] TESTS FOR PRESENCE OF SPECIFIC PATHOGENIC BACTERIA (STREPTOCOCCUS FAECALS; SALMONELLA TYPHII; VIBRIO CHOLERAE)

The location of 'Pani ki dharamshala' reservior is such that the surroundings may cause deleterious changes in its water quality. The habits of the local residents as well as the presence of temples next to the viscinity of reservoir have turned this water body into a dumping site. Inspite of its self replicating water source 'Jhir' the water seems to be a media for various organisms due to the organic wastes and sewage. If so

then sooner or later this reservoir may turn to be in hazardous condition for the neighbouring population.

The present study for presence of the bacteria was undertaken due to the enterance of sewage in the reservoir and presence of a private hospital nearby.

The general pattern of study followed was inoculation of water samples from the 3 sampling sites A, B and C on selective media plates (to study colony characteristics) followed by biochemical tests for confirmation.

EXP. 1 TEST PROCEDURE FOR STREPTOCOCCUS FAECALIS

S. faecalis grows along with E. coli in the lactose enriched medium used to test coliform bacilli used during presumptive test. It ferments lactose without production of gas. To test its presence in the water samples from three sampling stations, tubes from MPN counting showing acid production without gas formation were selected. Subcultures from these tubes were made in tubes containing 5ml sterile sodium azide medium. These tubes were then incubated at 45^0C for 48hrs. and then observed to check the presence of turbidity due to production of acid by the activity of S. faecalis.

Further the suspected cultures of S. faecalis were plated on Mac Conkey Agar through the inoculum from the above positive sodium azida tubes. These plates were then incubated at 37^0C, after incubation the plates were observed and colony characteristies were studied.

For further confirmation the suspected colonies were used as inoculum for biochemical tests and litmus milk test.

BIOCHEMICAL TEST

A typical colony suspected to be S. faecalis was picked up and suspension was prepared in sterilized water. A loopful of suspension was used to inoculate different biochemical media and part of it was used for gram staining. The observation of biochemical test were then recorded in the chart.

MEDIA PREPARATION FOR BIOCHEMICAL TESTS

[A] Fermentation Test

The fermentation tests were conducted against substrats – Mannitol, Sucrose, Arabinose, Sorbitol.

For the fermentation tests first a nutrient media was prepared. The nutrient medium used for the present study was peptone water to which indicator (Andred's indicator solution was added).

The nutrient medium along with indicator was dispensed in test tubes and durham tubes were inserted in an inverted position. These test tubes were then sterilized by autoclaving and cooled. Later sterile 10% solution of test compounds was added aseptically to each tube.

To these prepared tubes the suspension of suspected organism was inoculated and incubated.

[B] IMVIC TEST

This test comprise four different tests :

(i) Indole test

(ii) Methyle red test

(iii) Voges Proskauer test

(iv) Citrate utilization test

(i) Indole Test

The indole test was performed by inoculating the bacterium (from the suspected cultures) into tryptone broth. The indole produced during the reaction was detected by adding Kovac's reagent which produced a cherry red reagent layer.

First the inoculated tryptone broth tubes were incubated at 35^0C for 48hrs. and then 1ml of Kovac's reagent was added. The tubes were then examined carefully for development of cherry red colour in the top layer of the tube. Its presence revealed positive indole test.

(ii) Methyl Red Test

The test was employed to detect the production of sufficient acid. This test is used to differentiate two major types of facultative anaerobic enteric bacteria that produce acid and those producing neutral product acetoin.

The medium used for methyle red test was 'Glucose phosphate peptone' water – to prepare the media peptone and dipotassium hydrogen phosphate are dissolved in water.

5ml of this media was dispensed in the tubes and then sterilized for 15minutes.

10% glucose solution was prepared and sterilized seperately and then 0.25ml of this solution was added to each tube.

The liquid medium was then inoculated from young agar culture and incubated at 37^0C for 48hrs. After incubation 5 drops of methyl red reagent was added to the tubes and tubes were observed.

Positive test was indicated by appearance of red colour and negative test is indicated by yellow colour.

(iii) Voges Proskauer Test

V.P. test is done in conjunction with MR test and organisms producing acetyl methyl carbinol can be detected by this test, these organisms produced insufficient amount of Acid.

An organism of enterobacterial group is either Methyl red positive and Voges Proskauer negative or Methyle Red negative & Voges Proskauer positive.

The medium used for this test was the same as that used in methyl red test i.e. glucose phosphate peptone water. This liquid medium tubes after inoculation were incubated for 48 hrs. at 37^0C. After incubation 1 ml of 40% patassium htdroxide and 3 ml of 5% solution of $\propto$ Napthol in absolute ethanol is added in each tube. A positive reaction is indicated by development of pink colour in 2 to 5 minutes. This colour changed to crimson after 30 minutes. The negative test is indicated by no change in colour.

(iv) Citrate Utilization Test

This test is used to detect the ability of the organism to ferment citrate when used as a sole carbon source.

The citrate test was performed by inoculating the microorganisms into an organic medium – Simmon's Citrate medium agar. (ammonium dihydrogen phospate, dipotassium hydrogen phosphate, sodium chloride, sodium citrate, magnesium sulphate, agar and distilled water) Bromothymol blue was used as an indicator. When citric acid is used CO_2 is generated which combines with sodium and water forming sodium carbonate, an alkaline product due to this product the colour of the indicator changes from yellow to blue showing positive test.

[C] LITMUS MILK TEST

Litmus milk test is undertaken to check sachrolytic and proteolytic properties of bacteria by detecting whether they ferment lactose or digest casein.

Lactose fermenters when inoculated in litmus milk form acid and cause it to become pink. Large amount of acid precipitates the casein as a clot and gas formed during co-agulation disrupt the clot (stormy clot).

Proteolytic bacteria decompose milk protein to a transparent solution of soluble products. In litmus milk it is observed as a change to clear dark purple solution preceded by formation of a soft clot.

The medium used for this test comprises (a) Skimmed milk and (b) Litmus solution

Freshly boiled milk is allowed to stand to separate cream and milk. This milk is used for the test.

Litmus solution is prepared as under :

Litmus granules (8gms) are added to 30ml of 40% ethanol boiled for 1 min. The fluid is decanted and the remaining granules are dissolved in 15ml of alcohol, the solution obtained is then mixed with the original solution. 1 N HCl acid is then added drop by drop till the fluid becomes purplish in colour.

This litmus solution is added to the freshly boiled and cooled milk immediately as and when the test is to be conducted.

EXP. 2 TEST PROCEDURE FOR SALMONELLA TYPHII.

The water samples from the three sites A, B and C were brought in sterilized glass bottles.

To isolate S. Typhii from the samples, it was first inoculated in enrichment medium – Strontium selenite broth.

During incubation Salmonella grew rapidly. After 24hrs. loopful from the enriched culture was streaked on plates of two different media separately in aseptic conditions :

(a) Mac Conkey Agar (Bile salt lactose agar) (Peptone 20g, sodium chloride 5g, Bile salt –1.5g, Lactose 10g, neutral red solution 1% 10ml, crystal violet .001g. Agar 13.5g in 1000ml distilled water).

(b) Wilson and Blair's Brilliant green Bismuth sulphite agar (BSA) – (Peptone 10g, Dextrose, Na_2PO_4 – 4g; Ferrous sulphate – 0.3gms; Bismuth sulphate 8gm., Brilliant green 0.025, Agar 20g in 1000ml distilled water, pH 7.7)

The inoculated plates were then first incubated at 37^{0}C for 18 to 24hrs. and observed, then the BSA agar plates were subjected to further incubation for 48hrs..

Later the characteristics of colonies developed on the two media were studied and suspected colonies were further subjected to biochemical tests for confirmation.

BIOCHEMICAL TESTS

From the suspected colonies loopful was picked up and suspension was prepared. Each Biochemical media tubes were inoculated with a loopful of suspension for testing the action of the organism. Observations recorded were tabulated in the Table .

Part of the suspension was used for gram staining.

The following biochemical tests were conducted :

(a) **Fermentation Tests** – against the following substrats – glucose, maltose, sucrose, xylose , arabinose, mannitol and sorbitol. The procedure is same as mentioned above

(b) **H_2 S production.**

(c) **Imvic Test**

The procedure for IMVIC test is same as mentioned earlier.

H_2 S PRODUCTION TEST

The H_2S is produced by certain bacteria through reduction of sulphur containing amino acids. The hydrogen sulphide production can be detected by incorporating a metal salt containing Ferrous ion (Fe^{2+}) or Lead ion (Pb^{2+}) as a H_2 S indicator to a nutrient culture medium

containing Cystein. H_2 S when produced reacts with the metal salt forming black insoluble ferrous sulphide.

The ingredients used for the media preparation are – peptone, beef extract, sodium salt (either sodium chloride or sodium thiosulphate), iron salt (either ferrous chloride or ferrous ammonium sulphate), Agar and distilled water. All the ingredients except the ferrous salts are dissolved in water and autoclaved at 115^0 C for 10minutes. After removing from the autoclave it is cooled to 55^0C and ferrous salt solution is added to it. Media when dispensed in the tubes is inoculated with the organism and incubated at 35 to 36^0C for 48hrs.

The tubes were then examined for presence or absence of black colouration.

EXP. 3 TEST PROCEDURE FOR VIBRIO CHOLERAE

The water samples from the reservoir were first inoculated in the enrichment medium. The enrichment medium used was alkaline peptone water with 0.1 to 0.2% teepol (added to inhibit the growth of other contaminants). Water samples from sampling stations A, B and C was inoculated in enrichment media. These labelled tubes were then incubated at 37^0C for 6 to 8 hrs. and then subcultured on plates of :

1. Mac Conkey Agar. (Ingredients as described in Exp. 2). and
2. Selective Media – Monsur's medium (Monsur's medium is prepared using two solutions-

Bile salt gelatin Agar 100ml.

+

Potassium tellurite solution (0.05%) 1ml.

These plates were then incubated and the colonies developed were carefully observed. After observing the colony characteristics the suspected colonies were subjected to biochemical tests. The procedure is same as mentioned above.

STATISTICAL PROCESSING OF THE DATA OBTAINED

The guidelines for statistical analysis of the data collected was obtained from the work of Scheller (1969) – 'Standard Statistical Work'. The aid of computer for calculation was also used.

MEAN

Mean is the sum of all the members of a distribution, divided by the number of members in that distribution and was calculated with the help of the following formula :

$$\overline{X} = \frac{\Sigma x}{N}$$

STANDARD DEVIATION

It is the square root of the sum of squared deviations from the mean and was calculated by the following formula :

$$SD = \sqrt{\frac{EX^2}{N}}$$

STANDARD ERROR

Standard Error is ' the relation of standard deviation of a distribution with respect to square root of numbers in the distribution and hence also be called as standard error of the mean and was calculated with the following formula :

$$SE = \frac{SD}{\sqrt{N}}$$

VARIATION

$$Va = \frac{SD}{Mean}$$

SECTION - 3

REVIEW
OF
LITERATURE

SECTION –3

REVIEW OF LITERATURE

Hydrobiology or limnology is the study of water bodies and in the recent past has attracted many workers. The ever increasing rate of pollution and deterioration of water quality is causing concern in the mind of many workers and has attracted wider attention. This has stimulated studies on limnology in various kinds of water bodies, no matter small or big e.g. – Lakes, Rivers, Oceans, Ponds and Reservoirs etc.

In India many workers have contributed to the studies of Hydrobiology. Born (1979), however stated that substantial research in Lake Ecosystem is still needed. Based on Indian publication in Hydrobiologia, Gulati and Wurtz Schulz (1980) has analysed the present status of limnology and have suggested future lines needed for further work. R.G. Michael (1980) has presented a 'Historical Resume on Indian Limnology'.

Important works on lentic water bodies has been in progress since many years i.e. Iyengar (1940); Gonzalves and Joshi (1946); Ganpati (1943, 1955); Zafar (1959, 1967); Jana (1973, 1974, 1980); Hussain (1976), Das and Pande (1980); Palaniappan etal (1981); Zutshi (1982).

The hydrobiological studies were carried out in India for various water bodies : Ganpati 1955 made hydrobiological investigations of Stanley reservoir and river Cauvery; Krishnamurthy etal 1965 carried out hydrobiological studies on Gandhisagar tank; Dubey and Verma 1966 worked on hydrobiological studies of Budhwari Tank Seoni M.P. Kaushik etal 1988

studied hydrobiology of Viveknagar Pond, Gwalior M.P. U.S. Badge and A.K. Verma 1985 carried out limnological studies on J.N.U. Lakes, New Delhi.

Hedge and Bharti 1985 have studied trophic status of some ponds at Dharwar which received sewage.

Unni 1984, carried out limnological studies of a sewage polluted tank in Central India. H.M.Saran and A.D. Adoni 1985 carried out studies on 'Diurnal Variation of various parameters in Central Indian Reservoir.

Not only the natural water bodies (like lakes, river work and ponds) have been worked out but work has also been done on Waste Water Stabilization pond ecosystem ie. – P.R. Chaudari, A.V.J. Rao 1985 and many other workers.

The ground water pollution study has also been carried out by various workers like C. Naganna etal 1985 along coastal Karnataka; Banerjee 1983 studied the management plan of ground water in Calcutta. Handa 1983, 1986 studied hydrogeochemical zone in few places in India. Ramchandran etal 1991 revealed influence of agrochemicals on ground water quality. Elango 1992 – groundwater quality in coastal region of South, Mittal etal 1994 in Patiala.

Zutshi etal 1980 worked on comparative limnology of 9 lakes of Jammu and Kashmir.

Limnology of manmade reservoir on Westernghats in S. Kerela was studied by Thomas Sabu 1996. Work on estuaries has also been carried out by some workers e.g. K. Kalidasan and A.A. Rahman 1992. Naidu 1990 worked

on water quality of Temple tank and reservoir in Tirupati. Swain and Adhikari 1994 studied on quality of water of Swetganga temple tank, Puri. Z.D. Kanhere and V.R. Gunale 1997 worked on the status of urban water body.

During limnological studies various physico-chemical parameters have been worked out. The methods of analysis have been given by Welch 1948; Hutchinson 1967; Golterman 1969, 1978; A.P.H.A. 1967, 1980, 1985; Lind 1974; Adoni etal 1985; Das 1989; IS 30251964; I.S.I 1982; Greenberg etal 1975; Schwoerbel 1970 etc.

Detailed work on physico-chemical factors has been done as early as Juday in 1915-1916. This was followed by many more workers, the notable ones among those are as follows :

Correlation between physico-chemical and biological factors had been worked out by Ganpati 1955.

Physico-chemical parameters have been utilized to indicate the pollution level and quality of water. Hantge 1978 studied pollution of Nahe river in Germany. In India Das and Pande 1978a, b, studied lake pollution as induced by physico-chemical and biological parameters. Chandra etal 1984 worked on pollution in Rihand reservoir. Khanka 1983 studied physico-limnological analysis of Naina lake and Bhimtal lake in Kumaon. Shyamsunder 1988 studied the water quality of river Jhelum in Kashmir and concluded river water is becoming more and more alkaline day by day. Abundance of insects in relation to physico-chemical characteristics of pond water at Gwalior (M.P.) was studied by S.S. Kaushik, M.N. Sharma and D.N. Saksena 1990. Kaushik etal 1990 concluded that pollution load during summer months becomes greater in comparison to other months. Khanka 1991 studied

physical limnology of Himalayan lakes. Mishra and Saksena 1991 worked on pollution ecology with reference to physico-chemical characteristics of Morar (Kalpi) river Gwalior M.P.

S.P. Mishra and D.N. Saksena 1993 studied planktonic fauna in relation to physico-chemical characteristics of Guari tank at Bhind M.P. M.A.G. Khan and S.H. Chowdhury 1994 studied physical and chemical limnology of lake Kaptai Bangladesh. Arvind Kumar; H.P. Gupta and D.K. Singh 1996 studied about the impact of sewage pollution on chemical parameters and productivity of two freshwater bodies in Santhal Paragana.

Paka Swarnalatha and A. Narsingh Rao 1997 studied inter relationships of physico-chemical factors of Osmania University Pond, Hyderabad. Dhamija and Jain 1997 worked on polluted lentic water body of Jabalpur with special reference to physico-chemical and biological parameters. Chakravarty etal 1997 investigated abiotic factors like pH, temperature, dissolved oxygen, free carbondioxide, carbonate and bicarbonate alkalinity and correlated their role on plankton production in Monghyr (Bihar).

Krishnamurthy and Bharti 1997 revealed that high value of pH, conductivity, dissolved oxygen, bicarbonate and total hardness influence the occurrance of Euglenophyceae of Kali river around Dandeli, Karnataka.

Physico chemical characteristics and phytoplanktons of Taudah lake Kathmandu were studied by L.R. Bhatt, P. Lacoul, H.D. Lekhak and P.K. Jha. 1999.

Periodicity and interrelationships of physico-chemical factors in ponds was studied by Braj Nandan Prasad and Y.C. Jaitley 1985.

Notable contributions on studies on Diurnal variations in phytoplankton ecology of Tropical Indian Waters had been done by Ganpati 1955, George 1961, Verma 1967 and Kannan & Job 1980a and 1980b.

Few workers like Stahl and May 1967, Hartley and Weirs 1970, Merz etal 1957 have studied stratification in stabilisation pond effluents.

Ganpati 1955 also carried out studies on diurnal variation of dissolved gases, pH value and some of the important dissolved substances of biological significance in three temporary pools at Mettur dam.

Studies on diurnal and vertical distribution of phytoplankton in waste water stabilization pond were carried out by P.R. Chaudhary, A.V.J. Rao, J.P. Kotangale and K.P. Krishnamoorthi in 1985. Seasonal, diel and vertical periodicity with reference to phytoplankton production and physico-chemical parameters was studied by A.D. Adoni and A.K. Vaishya 1985.

R. Marimuthu and V.Krishanmurthy 1985 carried out diurnal studies of phytoplankton ecology in two small tropical pools of Rasipuram, Salem. H.S. Rawat, S.P. Badola and D.R. Khanna 1990, studied diurnal variation in certain physico-chemical parameters of Girital lake.

Diel variation of water quality and zooplankton community in a freshwater pond of Patna was studied by Meena (Swaroop) Singh and R.K. Sinha 1995.

The study of temperature factor is of importance in limnological studies as its variation influence the chemical and biological components of the ecosystem. This factor is usually included during the limnological studies and interpreted in various ways.

Welch 1952, stated that smaller the body of water more quickly it reacts to the changes in the atmospheric temperature.

This factor has been studied in detail by Young and Zimmerman 1956, Zafar 1971, Prasad 1983, Shiv Kumar etal 1989, Gupta and Mehrotra 1991 and Nalin K. Shastri etal 1991.

Correlation between temperature and phytoplankton has been done by various workers – Mc Combie 1953 stated that temperature may effect seasonal cycle of phytoplankton in temperate zone; Hutchinson 1957 said that temperature is an important factor which controls both quality and quantity of planktonic flora. Jana 1973 and Chari 1980 observed that temperature is a critical factor for seasonal periodicity of phytoplankton.

Many workers observed temperature factor of different rivers, some of these are – Saxena etal 1966 in Ganga at Kanpur, Verma and Dalela 1975 of Kali Nadi at Mansurpur, Dakshini and Soni 1979 in river Yamuna at Agra, Shah 1988 in river Jhelum at Kashmir, Sinha 1988 in R. Damodar, Ghosh and Sharma 1988 river Ganga at Patna, Rana and Parliya 1988 river Bandi.

Efford 1967 and Moss 1969 from their studies concluded that surface water temperature closely reflected to ambient air temperature. This is particularly true for shallow lakes and ponds.

Thermal stratification in different layers of stabilisation pond was observed by P.R. Chaudhari etal 1985.

A.D. Adoni and A.K. Vaishya 1985 during their limnological studies of central Indian reservoir observed that surface water temperature was lower than air temperature during day time and reverse trend was noticed during

night hours. A relative decrease with increasing depth during day hours was also evident while during night hours column remained more or less isothermal.

Dodakundi and Rodji (1974) said that temperature and light intensity are the factors which influence the pond dynamics.

Conductivity is a good and rapid method to measure the total dissolved solids and is directly related to total solids (Mishra and Saksena 1993). Many workers worked on this parameter and its effect, like Juday and Birge 1933; Rodhe 1949; Otsuki and Wetzel 1974; Trivedi etal 1985; Rawson 1960; Nalin K. Shastri etal 1991; Dakshini and Soni 1979; Mishra & Saxena 1991; L.R. Bhatt etal 1999.

pH is the important factor depicting the chemical and biological conditions of natural water. Various workers like Atkin 1922, Lund 1934, Shrivastav 1967, Gupta and Mehrotra 1986, Alabi 1971a, studied correlation between pH and water molds.

Pearsall 1930 and Zafar 1966 observed that pH of water appears to be dependent upon relative quantities of calcium, carbonate and bicarbonate.

Gonzalves 1946, Hannan and Young 1975, Zutshi & Vass 1978 while their studies observed seasonal variation in pH and found that maximum pH value was during summer low values were observed during winter and monsoon season.

pH of water also gives an idea to the type and intensity of pollution. Verma etal 1984, Saksena etal 1966 observed pH of Ganga river above 8 in all seasons except rainy. Chandraprakash etal 1978 found alkaline nature of

Jamuna river at Agra, Palhariya and Malviya 1988 recorded maximum pH 11.5 in Narmada river.

Baily 1963, Srinivasan 1963, Moitra and Bhattacharya 1965, Jana 1973 and Chari 1980 observed that high pH value was related to heavy bloom of phytoplanktons. S.K. Chaurasia and A.D. Adoni 1985 while their studies on a shallow eutrophic lake observed that high pH favours the plankton production, higher pH at surface and lower at bottom were associated with the photosynthetic activity.

H.S. Rawat, S.P. Badola and D.R. Khanna 1990 during studies on diurnal variation observed that pH slightly increased in the afternoon and decreased during night.

L.R. Bhatt etal 1999 while working on physico-chemical characteristics and phytoplanktons of Taudah lake Kathmandu found negative correlation co-efficient of pH with Cyanophyceae and Chlorophyceae and positive correlation co-efficient with Bacillariophyceae.

Chloride content of water has been studied by many workers like – Saksena etal 1966 on river Ganga at Kanpur, Laxminarayan 1965 on river Ganga at Varanasi; Munnawar 1970a and b on fresh water ponds of Hyderabad; Mahadevan and Krishnamchary 1983 on river Vaighi; Somashekhar 1984 on river Cauvery; Ajmal etal 1985, 1988 on Kalinadi; Brajnandan Prasad etal 1985 on four ponds in Lucknow; Palhariya and Malviya 1988 on Narmada river; Shah 1988 on river Jhelum; Ghosh and Sharma 1988 on river Ganga at Patna.

According to Thresh etal 1944 high chloride is generally the indicator of large amount of organic matter in water. Klein 1957 said that there is direct

correlation between chloride and pollution level. Munnawar 1970 stated that higher chloride content is an index of presence of pollutents of animal origin. Goel etal 1980 stated that it increased with the degree of Eutrophication.

Gonzalves and Joshi 1946 and Zafar 1964 and Rao 1971, 1972 reported seasonal variation in chloride contents and stated that high chloride concentration was observed in summer season when water level was low and decrease in its concentration was observed in monsoon season.

Khulbe 1981 found that chloride content had an adverse effect on the fungal occurrence. According to Gupta and Mehrotra 1991 chloride contents of water shows an inverse relationship with temperature and fungi.

Dissolved oxygen is essential to maintain biological life in water. Its value is affected by waste discharges. Wetzel 1983 stated that oxygen content is an important requirement of many organisms. It affects the solubility and availability of many nutrients, therefore determines the productivity of aquatic ecosystem. Some important previous works on tropical waters concerning oxygen distribution were those of Fritsch 1907, Alikunthi etal 1948, 1951; Singh 1955; Chandraprakash etal 1978 on Yamuna; Mahadevan and Krishnamchary 1983 on river Vaigai; Palhariya and Malviya 1988 on Narmada river at Hoshangabad; Shah 1988 on river Jhelum Kashmir etc.

Kudesi 1985 said that low content of DO is a sign of high organic pollution tolerance limit (it is not less than 6 mg/L).

Seasonal variation of oxygen in water depends upon temperature of water which influences oxygen solubility, Zutshi & Vass 1978. Hannan 1979 and Agrawal etal 1976 said that dissolved oxygen depletes due to high temperature in summers. N.C. Datta etal 1985 while studying ecology of

Brackish water impoundment found that the concentration of dissolved oxygen was fairly high due to number of factors as shallowness of Bheri, high precipitation; moderate temperature salinity and photosynthetic activity of phytoplankton. S.K. Chaurasia and A.D. Adoni 1985 while their studies on shallow Eutrophic lake found higher value of dissolved oxygen in winter in comparison to rainy and summer seasons (similar trends had been reported by Hussainy 1967 and Adoni 1975). However Unni 1984 while working on sewage polluted tank in Chindwara found that in surface water highest dissolved oxygen was found in summer mainly due to high photosynthetic activity. Choudhary etal 1985 studied diurnal variation in dissolved oxygen at different water levels in waste stabilization ponds along with vertical distribution of plankton. Alabi 1971b, Manoharachary 1978 and Mishra 1991 observed inverse relation between dissolved oxygen and temperature, other workers who had found the same are Welsch 1957, Hussainy 1967; Zutshi and Vass 1978; Singh and Mahajan 1987; Gupta and Mehrotra 1986, Yadav etal 1987, H.S. Rawat, S.P. Badola and D.R. Khanna 1990 however found positive correlation between dissolved oxygen and temperature. Ganpati 1940 and Nasar and Munshi 1974 reported that temperature is not always the chief controlling factor of oxygen content but algal blooms and macrophytes play an important role.

Decomposition of organic matter always plays an important role in consumption of dissolved oxygen, which is more vigorous during warm weather- Gonzalves & Joshi 1946; Morisette and Mavinic 1978.

Hannan etal 1978, Hannan 1979 said that water becomes oxygenated during monsoon due to circulation and mixing by inflow after monsoon rains.

L.R. Bhatt etal 1999 during studies on Taudah lake revealed that the value of dissolved oxygen was below the tolerance limit (6mg/L) during summer due to high trophogenic activities and increased in rainy and winter season. Reoxygenation progressed in winter. Same results had been obtained by Udash 1996 in Tomar lake Kathmandu and Thapa 1994 in Kirtipur pond. However Yadav 1996 observed higher values in June and low in August in the same lake.

Paka Swarnalatha & A. Narsinghrao 1997 found negative relationship between dissolved oxygen and organic matter due to utilization of oxygen for oxidation of organic matter. S.L. Narshimha Rao and K.S. Murthy 1997 studied dissolved oxygen by new of Photometric Estimation Method.

Reduction in oxygen during warmer months due to respiration and decomposition of organic matter was also reported by Singh 1995, Patel and Sinha 1998 and Singh and Rai 1999.

Biochemical oxygen demand (BOD) is good indicator of organic pollution and helps in deciding the suitability of water. Notable works on BOD of water has been done by many workers like Zafar 1966, Zutshi and Vass 1982, Shardendu and Ambasth 1988 etc..

Mc Vea and Boyd 1975 during their studies on fish ponds reported lower BOD value due to the presence of aquatic plants.

Agrawal etal 1976 and Rai 1978 found highest value of BOD during summer and lowest value in winter, similar trend was reported by U.S. Bagde and A.K. Verma 1985 during their limnological studies on JNU lake New Delhi. Zutshi & Vass 1982 and Nalin K. Shastri explained that low value in

colder months was due to low quantity of solids and low quantitative values of microbial population.

H.V. Tilwankar, T. Appa Reddy and C.U. Rao 1989 studied the factors affecting BOD kinetics and reported that BOD is affected by dilution, toxic materials pH and temperature.

L. Shrotriya and P.S. Dubey 1991 said that sewage dominated waters have lower BOD load than water bodies receiving industrial effluents.

L.R. Bhatt etal 1999 observed maximum BOD in summer and lowest in winter season. According to them this was due to high rate of organic decomposition during summer. They reported that temperature decline during monsoon and winter retards the microbial activity.

Carbon dioxide is an essential factor of water ecosystem. Free carbon dioxide is suggested to be due to rain, plant roots and decaying vegetation. (A.M. KH. Jarousha 1999).

Welch 1952 reported that high carbon dioxide value in water can be attributed to higher decomposition of organic matter which leads to release of more carbon dioxide. Many workers like Whipple and Parker 1902; Birje and Juday 1911, Pearsall 1930, Ganpati 1943, Gonzalves & Joshi 1946, Raw 1964, Saha etal 1971, Singh 1965, Mandal and Hakim 1975 worked on various physico-chemical parameters of water and observed inverse relationship between carbon dioxide and dissolved oxygen. Manoharachary 1979 and Rao and Manoharachary 1983 showed its correlation with microbial members.

According to Munawar 1970 and Rao 1972 carbon dioxide was usually found to be more during summer with simultaneous low value of dissolved

oxygen. Similar trend was observed in Ramgarh lake of Jaipur by A.M. KH. Jarousha 1999.

According to Gupta and Mehrotra 1991 in Brahma Sarovar tank Kurukshetra free carbondioxide and occurance of water molds showed direct correlation with each other.

Johnson 1996 suggested certain factors like temperature, pH and total alkalinity to be responsible for solubilization of carbon dioxide.

Studies on alkalinity caused by carbonates and bicarbonates were carried out by various workers : Zafar 1966 found higher carbonate concentration in water bodies during summer stagnation period. Munawar 1970 found higher values of bicarbonate during winters in sewage pond. Rao 1972 observed its maximum values in late summer and early winter and minimum values of carbonate/bicarbonate in monsoon season.

Studies on alkalinity caused by carbonates had been carried out by Moss 1973, he concluded that in Eutrophic waters high bicarbonate concentration is found. S.K. Chaurasia and A.D. Adoni 1985 while their studies on shallow Eutrophic lake in Sagar observed that bicarbonate alkalinity and carbondioxide showed positive relation while bicarbonate and carbonate alkalinity showed inverse relation with each other.

Lowest value of carbonate alkalinity was observed by them during rainy season and maximum in summer season while bicarbonate alkalinity was high in rainy and low in summer season. Carbonate content was usually found by them to be higher in surface water as compared to bottom water in contrast to Bicarbonate alkalinity.

Studies on Diurnal and Vertical distribution in waste water stabilisation pond at Nagpur were carried out by P.R. Chaudhary etal 1985. They found that bicarbonate alkalinity was low throughout the depth of pond during afternoon and was very high during night. Carbonate alkalinity show even distribution throughout the depth however low during day and increase during night.

A.D. Adoni and A.K. Vaishya 1985 while working on Central Indian Reservoir found that carbonate alkalinity was maximum during summer and minimum during winter season. No regular diel pattern was observed except that slightly higher during day hours than the night hours. Bicarbonate alkalinity also did not show marked diel variation however it was found to increase with decreasing depth.

A.M.KH. Jarousha 1999 worked on Ramgarh Lake in Jaipur and found maximum value during monsoon. Similar results were recorded by Lakshmannan etal 1996, Singh and Rai 1999 and Bath & Kaur 1999.

Phenolpthalein alkalinity was studied by Nasar 1983, Hegde and Sujata 1996; Suvarna and Somashekhar 1977.

Total alkalinity plays a prominent role in altering the pH value so as to cause a change in flora and fauna according to Nygard 1949, Ganpati 1960, Tandon and Singh 1972; Moss 1973, Rana 1977 etc. Whipple and Parker 1902, Moss 1973 carried out studies on alkalinity caused by dissolved carbondioxide.

Mandal and Hakim 1975 found direct correlation between free carbondioxide and bicarbonate alkalinity in freshwater pond at Bhagalpur.

Previously Pearsall 1930, Howland 1931, Zafar 1964 and Munawar 1970 b had also reported similar correlationships.

Gupta and Mehrotra 1986, 1991 observed that total alkalinity and temperature show direct correlationship with each other while Total Alkalinity showed inverse correlation with water molds.

According to Reid 1961, Calcium played a significant role in biological productivity. Palmer 1967 recorded higher concentration of Calcium in contaminated waters. M.R. Kundangar and D.P. Zutshi while working on two Himalayan lakes stated that high levels of Calcium in water absorb labile organic substances and limit the plankton growth. The same was also reported by Zutshi and Vass 1973 in Dal Lake, Srinagar.

Braj Nandan Prasad, Yogesh Chandra Jaitley and Yashpal Singh 1985 worked on periodicity and inter relatioship of Physico-Chemical factors in Ponds at Lucknow and found that the effect of periodicity did not show and fixed pattern in Calcium content. Two peaks were observed one in summer season and second in winter season.

Kaiser Jamil 1991 said that Calcium content increased in water containing plants mainly hycinth as Calcium ions are important in regulating a wide variety of biological activities. Gupta and Mehrotra 1991 concluded that Calcium hardness may play an indirect role in the growth and occurance of water molds.

Close affinity between Magnesium concentration and organic pollution has been suggested by various workers. Zafar 1964, 1966, Munawar 1970 and Rao 1971 found direct correlation between Magnesium content and organic

matter of water bodies. Palharya and Malviya 1988 suggested higher value of Magnesium in river water is an index of pollution.

A.M.KH. Jarousha 1999 while working on Ramgarh Lake found lower magnesium content than calcium content at all sampling stations. Similar observations were reported by Dakshini and Soni 1979, Reddy 1984 and Nirmala Kumari 1994.

Twort etal 1974 classified water having hardness upto 75 mg/L as soft, 76-150 mg/L as moderate 151 to 300 mg/L as hard and more than 300 mg/L as very hard.

Singh 1979 found higher hardness values during summers.

Brajnandan Prasad etal 1985 observed higher hardness values in ponds which were more polluted than those which were less polluted. This observation was in line with that of Moss 1973 who also associated increase in hardness with increased Eutrophication.

U.S. Bagde and A.K.Verma 1985 during Limnological studies of JNU Lake found that Calcium and Magnesium hardness of Lake increased towards winter and summer and this they attributed to the steady state of hardening of water due to evaporation of surface water. Excessive dilution of heavy rains is responsible for lowering the hardness in Monsoon season. This pattern of successional hardness was also reported by Boznaik and Kennedy 1969, Daborn 1976. Kaiser Jamil 1991 found that hardness increased in water in presence of aquatic plants.

A.M. KH. Jarousha while working on Ramgarh Lake Jaipur reported the water to be hard and the hardness ranged between 118 to 255 mg/L. Similar

results have been recorded by Krishnamurthy and Bharti 1995 in river Kali at Karnataka while Pujari & Sinha 1999 gave similar reports from Orissa.

Study of Phytoplanktons is an essential part of hydrobiological analysis of water bodies as their qualitative and quantitative analysis have been correlated with pollution. Several reports on Algae of water bodies have been published from time to time by different workers – Lund 1961, Vyas 1968, Tripathi and Pandey 1990; Parvateesam etal 1991; Parvateesam and Mishra 1993; Shaji and Panikkar 1994; Jain and Shrivastav 1998; Kanhere and Gunale 1977; Tarar etal 1998.

Palmer 1969 listed algae tolerating different kinds of pollution and compared them with clean water algae. Change in species composition was reported by L.Shrotriya 1987. Temperature as a vital factor for growth of algae has been reported by Lund 1949; Rao 1955, Hutchinson 1967; Young etal 1972; Vasishtha & Sharma 1975; Verma and Duttamunshi 1987; Wisharad and Mehrotra 1988 reported proliferation of phytoplankton from winter to summer.

The water bodies receive large quantities of raw sewage and agricultural run off as a result of which high nutrient concentration of water and presence of dense phytoplankton population have been observed by Moss 1972, Prasad etal 1976, Sengupta etal 1988, Brij Mohan etal 1989. Phytoplanktonic compositon of sewage polluted Morar (Kalpi) river, Gwalior has been studied by S.R. Mishra, D.N. Saksena 1993.

Dominance of blue green algae during rainy season has been attributed to high nitrate values by Mesfin and Belay 1989, Goel etal 1997 and Kaur etal

1997. High number of blue green algae has been assigned to carbondioxide by Mallik & Base 1987 and to high alkalinity by Rao 1953.

Dominance of diatoms has been reported by Pal Santra 1990 and Mam 1995.

Kumar etal and Zutshi, Pant etal 1980 considered abundant algal growth as indicator of Eutrophication. Raanibai and Ravichandan 1987 attributed occurance of diatoms in good numbers to healthy unpolluted conditon of water body.

Cebacades and Brogueija 1987 emphasised that growth and photosynthesis of algae is mainly influenced by pH and alkalinity of water. Venkateshwarlu etal 1994 used algal species as indicators of pollution gradient.

Hydrology and periodicity of phytoplankton in sewage fed Motia pond Bhopal was studied by Taiyyab Saify, S.A. Chagtai, Alis Parveen, I.A. Durrani 1986.

Algal flora has been considered as an indicator of organic pollution, on this basis assessment of water quality of Vishwamitra river, was done by S.N. Nandan and R.J. Patel 1986.

Primary productivity of Phytoplanktons has received due attention since past few decades. According to Westlake 1963 macrophytes are more productive than phytoplankton communities in small water bodies, however in lakes, oceans and rivers macrophytic productivity is less than that of phytoplankton. Some important contributors of past are Lund 1964, Ganpati and Sreenivasan 1968, 1970, 1972; Hussainy 1967, Quasim 1969, Khan and Zutshi 1979, Adoni 1975, Kannan and Job 1980, Awatramani 1980, Saran

1980 etc. Sreenivasan 1965, 1968, 1969, 1970 and 1972 had worked on inland waters, Reservoirs and Tanks of Tamil Nadu. Tundishi 1980 had reported that number of factors influence primary productivity Findenegg 1965, Qasim etal 1974, Khan and Zutshi 1979 found that Ultraplankton and Nannoplankton assimilate much more carbon than net phytoplanktons like diatoms or blue green algae. Primary productivity of Indian rivers and streams whether clean or polluted has been studied by Rajyalakshmi and Premswarup 1975, Ramarao etal 1979, Gupta 1982 and Patra 1985. H.M. Saran and A.D. Adoni 1985 while studying seasonal variation in Phytoplanktonic primary productivity in Sagar Lake found that productivity was high during summer. High ratio indicate high NPP and low respiration. N.C. Dutta, B.K. Bandhopadhyay and N. Mandal 1985 while working on ecology of Brackish water impoundment found that Primary Productivity showed bimodal pattern with two peaks one in April and other in November. Productivity is negatively correlated with temperature and dissolved organic matter and directly with dissolved oxygen and salinity. Vijayaraghav 1971 worked on seasonal fluctuations in production of tropical ponds and obtained values ranging from 1.5 to 15.8 $gc/m^2/day$. S. Ayappan and T.R. Chandra shekhar Gupta 1985 worked on Limnology of Ramsamudra Tank found maximum production during summer, surface water generally recorded higher rates of GPP. Production was generally controlled by several hydrographic factors such as pH, free Carbondioxide, total alkalinity and hardness of water.

A.D.Adoni and A.K.Vaishya worked on seasonal Diel, Vertical variation and periodicity in Phytoplankton production of Central Indian Reservoir and observed higher productivity in summer season coincided with higher air & water temperature and light intensity. This is in accordance with the

observations recorded by Qasim etal 1969, Vijayraghavan 1971, Adoni 1975, Sharan 1980, Sharma 1983 and Bhatnagar 1984. A comparison of Primary Production and Production efficiencies of the tank with other Indian freshwater habitats were carried out seperately by Sumitra 1971, Sreenivasan 1972, Nasar and Datta Munshi 1975, Mehra 1986.

Shukla etal 1989 have found that primary productivity of river Ganga at Varanasi is adversely affected by industrial effluents and untreated city sewage released into the river. Verma & Dattamunshi 1989 found that light intensity, photoperiod and rainfall influence primary productivity in flowing waters.

Jhingran and Pathak 1988 have shown that productivity potential of river Ganga was minimum at polluted site at Kanpur, it increased reaching maximum at Allahabad where water quality improved.

Sinha etal 1990 found low primary productivity during winter season. S.R. Mishra and D.N. Saksena 1992 worked on primary productivity in a sewage collecting channel of Morar (Kalpi) Gwalior.

The role of minor nutrients in limiting the productivity of aquatic systems was studied by C.R. Goldman 1972.

Vijay Valeeha and G.P. Bhatnagar 1989 worked out primary productivity of Phytoplanktons in Eutrophic lower lake of Bhopal and found that primary productivity was quite high without any definate seasonal pattern. Light penetration curtailed due to self shading of planktons which resulted in reduction of productive zone Phytoplankton Productivity in few tropical ponds was studied by R. Bhaskaran, V.S. Namberajan and N. Alagu chamy

1991. Arvind Kumar, H.P.Gupta and D.K.Singh 1996 studied impact of sewage pollution on primary productivity of two freshwater bodies of Santhal Pargana and observed that high rate of primary production indicates faster rate of Eutrophication.

The dissolved or suspended organic matter in water serves as a substrate for microbial growth. Microbial activities on aquatic organic matter and its effect on biological activities of phytoplankton have been revealed by studies of Basu 1965. Goldreich 1965 and Foster etal 1971 reported that Eutrophic water supported growth of different kinds of organisms. Vijayaraghavan 1971, Shardendu etal 1980, Bagde and Verma 1991 observed that higher temperature favoured the growth and multiplication of Coliform bacteria. Golterman 1976 suggested that increase in temperature may effect growth of organisms positively or negatively depending upon the species.

According to Rheimheimer 1978, high temperature exert a harmful effect upon the survival of some organisms especially those capable of producing disease. Morisette and Mavinic 1978 found that microorganisms need Oxygen to maintain their metabolic process. According to Gonzalves and Joshi 1965, Mannan 1979 there is an inverse relationship between coliform count and dissolved oxygen. Bagde and Verma 1991 studied interaction between coliform bacteria and physico chemical parameters. They observed direct correlation between coliform bacteria, pH and electrical conductivity.

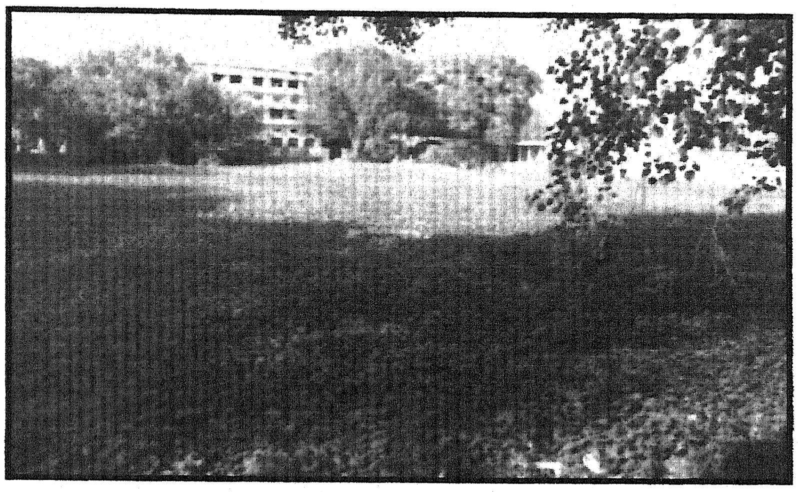
R. Kapur, Archana Sharma and Sajjan Khan 1990 studied bacterial incidents of polluted water and their emerging antibiotic resistance.

Verma and Paul 1996 found that bacteria can survive more successfully under warm conditions. Paniker and Ravindran 1997 stated that Coliform and

other bacteria have ability to survive in various aquatic environment for considerably long period, they reported average survival of S. Typhii for 34 days. Mogal and Dube 1995 worked on heterotrophic bacterial population of waters of Dandi sea coast.

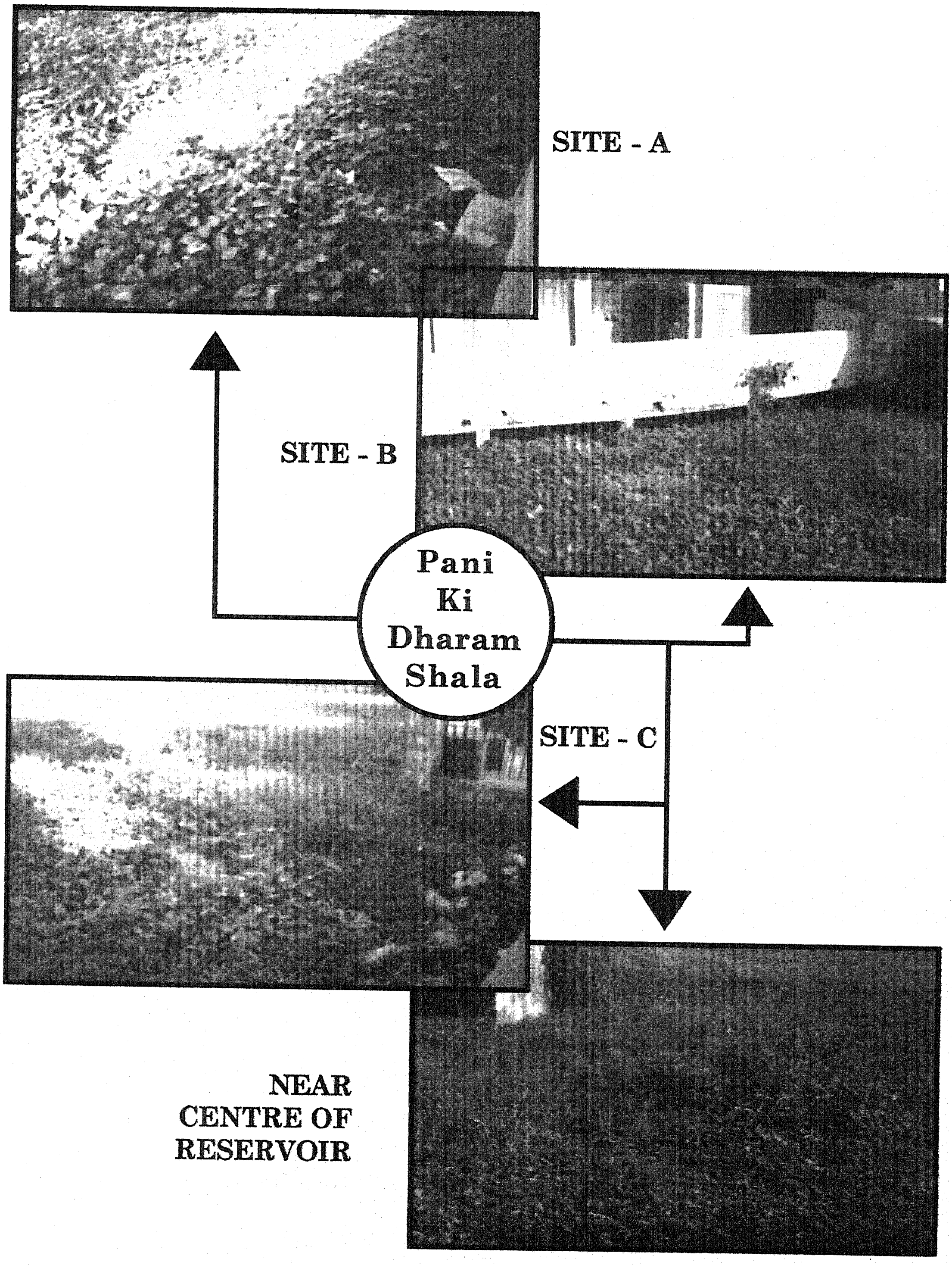
A.M. KH. Jarousha 2000 worked on polluting elements of Ramgarh lake of Jaipur and said higher values of Coliform, faecal Coliform total bacterial counts can be attributed to the run off water during monsoon which carry different kinds of organic matter.

PLATE-4



Prevalance of Ipomoea species along with other Angiosperms (28 June 2000).

PLATE-5



Spots cleared for collection of sample amidst thick coverage of hydrophytes & grasses.

SECTION - 4

PHYSICO CHEMICAL STUDY. OBSERVATIONS.

A. FORT NIGHTLY STUDY

B. DIURNAL VARIATION.

SECTION –4 CHAPTER'A'

PHYSICO – CHEMICAL STUDY

FORTNIGHTLY OBSERVATIONS OF PHYSICO CHEMICAL STUDY

The physico-chemical factors operating in the Reservoir were assessed fornightly for three different sampling stations A, B, C and at two water levels at each sampling station A_1, A_2; B_1, B_2; C_1, C_2. A_1, B_1, C_1 being the samples from upper level near the surface, A_2, B_2, C_2 being the samples from the lower level-about 5-6 ft. depth. The values of different parameters showed variation at the two levels as well as at each sampling stations in different months. The impact of physico-chemical parameters on planktonic periodicity and productivity was also recorded.

The observations were recorded for one year from October 1999 to September 2000 at fortnight intervals and tabulated in Table 2 to Table 13.

The findings and observations are described as follows :-

1. COLOUR & TURBIDITY

Water samples at different sampling stations varied with reference to Colour & Turbidity. At sampling station 'A' usually the water was colourless without any turbidity during the entire study period. At sampling station 'B' the water was found to be colourless except in June, when yellowish water was recorded.

Turbidity was recorded during the months of Oct, December and January. In December its intensity was higher as compared to October and January. At sampling station C water was generally turbid and was quite high during the months of Oct, Nov. and Dec. 99, while during Jan, Feb and March it decreased andagain in May, June it increased. During July, August and September water was clear with some suspended particles.

2. WATER TEMPERATURE

Water Temperature was recorded at site at the time of sampling (usually between 8.30 to 9 am). The Temperature was recorded at different sampling stations of the water samples from the two different depths.

Water Temperature showed seasonal variation. At the same time water temperature differed at different sampling stations depending on the location and surroundings. Sampling stations A and B are under shade of trees and temples. Sampling station C is totally exposed to sunlight. Hence it was observed that water temperature recorded at A and B was comparatively less than that of sampling station C.

The readings of the two levels represented slight thermal stratification as there was difference of approximately 1 to 2^0 C between surface water temperature and temperature of water sample from 5 ft. depth. Temperatures were generally low during November, December, January and February while during the rest of the months it was high.

<u>**Water Temperature variation at Sampling Station A**</u>

The temperature ranged between 17^0C to 29^0C. Maximum surface water (A_1) temperature was recorded to be 29^0C in the first week/fortnight of July 2000 and minimum was 17^0C in the first week of January 2000.

The maximum temperature of water from depth (A_2) was recorded to be 27^0C in the first week of July 2000 and minimum of 16^0C in the 1st week of January 2000.

Water Temperature Variation at Site B

The maximum value of surface water temperature was recorded in the first week of July 2000 where it was 30^0C. The minimum of 18^0C was recorded in first and second fortnight of January 2000.

At the depth of 5 ft. B_2 maximum water temperature was 29^0C in the first fortnight of July 2000 and minimum temperature was recorded to be 17^0C in first fortnight of January 2000.

Water Temperature Variation at Site C

Here the maximum surface water temperature value was recorded in the month of October 99 first fortnight i.e. 30^0C. The minimum value was however recorded in the same month as at other sampling stations i.e. in first fortnight of January 2000 and was 17^0C.

At the lower depth (C_2) the maximum water temperature recorded was 30^0C in first fortnight of October 99 and minimum of 15^0C in second fortnight of January 2000.

The values are recorded in Table II & variations depicted in Fig. 2.

3.pH

Variation range of pH was narrow ranging from 7 to 9. In general the pH of water at different sampling stations was towards alkaline side.

Lowest value of pH was usually recorded during the winter months and highest value during summer months. During rainy season the value was comparatively lower than in summer and higher to those of winter months.

The datas obtained at different sampling sites have been recorded in the Table III and Figure 3.

The datas recorded are being referred below, site wise :-

At Sampling Site A

At this site samples for pH were collected from surface water and at a depth of 5 fts. Surface sample has been referred as A_1 and that of depth has been referred as A_2.

At A_1 sampling site the pH value from October 99 to February 2000 ranged between 7.4 to 7.6 i.e. almost the same with minor fluctuations. From February onwards the value was found to be increasing and till July it remained in the range of 8.0 to 9.2. Here again some fluctuations were observed as shown in the figure 3. During August 2000 and Sept 2000 the value remained constant to 8. In general these values showed that the water was slightly alkaline with least values during the winter months, highest values during the summer and moderate values during the rainy season.

At A_2 i.e. at the lower level the pH generally remained lower than that of the upper level, however during the rainy season at times slightly higher pH was also recorded. The highest value was recorded during April 2000 and the lowest value was recorded during January 2000 at both the levels.

At Sampling Site B

At this site also water for pH was examined of the two levels. At B_1 the pH recorded was in general slightly higher or equal to that of A_1, only at few places lower pH values were obtained. From October 99 to March 2000 the pH remained between 7.3 to 8.1 with minor fluctuations. From April to september 2000 the pH ranged between 8.0 to 9.2. Again higher values were recorded during summer months, lower values during winter months and moderate during rainy season. At B_2 similar trends were found as followed during the analysis of samples at A_2 that is lower values at depth and higher values at the surface with occasional reverse position. Highest value was observed during May and lowest during February 2000.

At Sampling Site C

The seasonal variation showed the similar trend as that found at other two sampling sites A&B. Higher values were recorded during summer months, moderate values during rainy season and lower values during winter months.

The value of pH was found to be more in upper level water than in lower level during major part of the study period.

At C_1 the highest value was recorded in April 2000 second fortnight and was 9.2. The lowest value was recorded in January 2000 and was 7.1

At C_2 highest value recorded was 9 and it was recorded in September 2000 (second fortnight). This however represents a different trend as at other sampling stations the highest values were recorded in summer months. The lowest value was recorded in December 99 (second fortnight) and was 7.0.

4. CONDUCTIVITY

The value of Conductivity was rather very low ranging from 0.4 to 0.8 mMhos. For maximum part of study period the value recorded was 0.8 mMhos at all the three sampling stations studied.

The minimum value of Conductivity was observed during the month of December 99 at all sampling stations (0.4 to 0.6).

Mostly the value of Conductivity varied between 0.7 to 0.8 mMhos. Lower values observed in December 99 and August 2000 with December 99 showing lowest value followed by August 2000. Values of conductivity were found to be similar at the two levels with occasional variation of 0.1 mMho.

5. CHLORIDE

In the first week of October 99 the Chloride content was very low ranging from 3.99 mg/Lit – B_2 (Sampling Station B lower depth) to 14.49 mg/Lit at A_1 (Sampling station A upper level).

The lowest value of Chloride content was recorded to be 3.99 mg/L in October 99 at the sampling site B_2 and highest value was 163.45 mg/L at sampling site B_1 in December 99 during the first fortnight.

Usually the value of Chloride content was found to be more at upper level of water than at lower level, however from January 2000 to March 2000 and Aug. 2000 the reverse was observed, i.e. the upper level water showed low Chloride content and lower level water recorded higher Chloride content comparatively.

AT SAMPLING STATION A

At the upper level the Chloride content varied from 14.49 mg/L to 138.96 mg/L. Minimum value was observed in October 99 in first fortnight and maximum value was observed in September 2000 in second fortnight.

In the midst of fluctuation three rising peaks were recorded :-

In December 99 – 133.96 mg/L then it declined Second peak in April 2000 (Second fortnight) – 113.46 mg/L then it declined and third peak in September 2000 (second fortnight) 138.96 mg/L.

At the lower level (A_2) no fixed pattern of rise and fall of Chloride content was observed. The minimum value recorded in October 99 in first fortnight was 10.49 mg/L and maximum of 118.96 mg/L in December 99 second fortnight.

AT SAMPLING STATION B

Lowest value recorded was 4.49 mg/L in October 99 during the first fortnight at upper level of water (B_1). Maximum value recorded was in December 99 first fortnight and was 163.45 mg/L and a decline was noted upto January 2000 second fortnight. In B_1 Chloride content gradually increased from February 2000 (second fortnight) to May 2000 first fortnight.

In the water sample of lower level (B_2) minimum value of Chloride content was 3.99 mg/L in October 99 (first fortnight) and maximum value was 126.96 mg/L in September 2000 second fortnight.

AT SAMPLING STATION C

Two peaks of rise in Chloride content were observed at the upper level of water (C_1), the first peak in December 99 and second in September 2000. Minimum Chloride content recorded was 9.99 mg/L in October 99 first fortnight and maximum value was 131.46 mg/L recorded in September 2000 second fortnight.

The lower level water – C_2 Chloride content was found to be maximum in June 2000 second fortnight when its value was 143.96 mg/L. Minimum value was of 7.49 mg/L recorded in October 99 first fortnight.

Usually it was observed that the Chloride content was higher in summer season at all the sampling stations except C_2. The average seasonal value was higher in summer season at A_1, A_2, B_1, B_2 and C_1 sampling stations while at C_2 sampling station it was higher in winter season. Lowest amount of Chloride content was observed in Rainy season at A_1, A_2 B_1 B_2 & C_1 while at C_2 the lowest value was observed in summer season.

According to the datas recorded in Table VB the average seasonal values at different sampling stations are as follows.

AT SAMPLING STATION A

Highest average value of the Chloride content was found in summer season in water from both upper and lower level. The value being 120.60 mg/L in upper level (A_1) and 76.66 mg/L in lower level (A_2). In winter season moderate amount of Chloride content was recorded. Minimum average seasonal value was observed in Rainy season in water from both the level, the values being – 66.79 mg/L in A_1 and 69.54 mg/L in A_2 (lower level).

AT SAMPLING STATION B

Seasonal variation was similar as recorded at sampling station A with highest average value in summer season in both the levels – 93.78 mg/L being at B_1 upper level & 85.67 mg/L at B_2 lower level.

The moderate values were recorded in winter season and lowest average value recorded in Rainy season. Lowest value in upper level was 61.97 mg/L & in lower level water (B_2) the lowest average value was 63.04 mg/L.

AT SAMPLING STATION C

Sampling Station C however showed a bit different trend as compared to the other two sites as highest average seasonal value of Chloride content was recorded in winter months in lower level water (C_2) the value being 88.03 mg/L and lowest value of 65.54 mg/L in summers.

In the surface water higher values were recorded in summer season & lowest value was recorded in Rainy season. The highest average value being 76.23 mg/L & lowest average value being 66.73 mg/L.

6. DISSOLVED OXYGEN

The Dissolved Oxygen was found to be usually more in surface water than in the water at depth except in April 2000 & June 2000 1st fortnight.

Maximum values of Dissolved Oxygen (DO) were observed in Oct. 99 at all sampling stations, thereafter gradual decrease was observed upto Dec. 99 first fortnight, thereafter the values increased and fluctuated. Minimum value was observed usually in June 2000 (first fortnight).

The maximum value of D.O. recorded in the water of Reservoir was 40 mg/L recorded at B_1 in October 99 and minimum value of 3.02 mg/L at B_1 & C_1 in June 2000.

AT SAMPLING STATION A

Maximum value observed in surface water (A_1) was found to be 24.19 mg/L in October 99 first fortnight. The lower level water (A_2) showed maximum value 22.18 mg/L in October 99 first fortnight. Minimum amount of Dissolved Oxygen found in surface water was 4.03 mg/L in June 2000 first fortnight. At lower level (A_2) the minimum amount of DO was 5.04 mg/L in June 2000 (second fortnight).

AT SAMPLING STATION B

The same trend was observed at B sampling station as that found at sampling station A.

Maximum value in surface water (B_1) was 40.32 mg/L in Oct. 99 second fortnight and minimum amount of DO was 3.02 mg/L recorded in June 2000 first fortnight. At the lower depth the maximum amount of Dissolved Oxygen observed was 36.29 mg/L in October 99 second fortnight and minimum value was 4.03 mg/L in June 2000 first fortnight.

AT SAMPLING STATION C

At sampling station C the water sample from upper level that is C_1 showed the maximum value of 34.27 mg/L in October 99. Minimum amount of Dissolved Oxygen was recorded to be 3.02 mg/L in June 2000 (first fortnight). In Water at depth showed maximum dissolved Oxygen of 31.29

mg/L in October 99 (second fortnight) and minimum value was 4.64 mg/L in January 2000 (second fortnight).

7. BIOCHEMICAL OXYGEN DEMAND (BOD)

The values of BOD showed great variation ranging from 3.92 mg/L minimum value to the maximum of 29.51 mg/L.

Usually higher values of BOD was observed during summer months and lower values were observed during winter months and moderate in Rainy season. It was often observed that surface water had higher value of BOD than water at depth.

At all sites the minimum value was recorded in the month of January 2000 and the maximum values were recorded in April 2000 except in water sample A_1 where it was observed in March 2000.

AT SAMPLING STATION A

In the earlier part of the study period a gradual decline in the value of BOD was observed from October 99 second fortnight to January 2000 first fortnight.

The minimum value recorded in surface water (A_1) was 4.18 mg/L in January 2000 first fortnight and the maximum value recorded was 23.20 mg/L in April 2000 in first fortnight. The decline in BOD value of surface waters started from second fortnight of April 2000 and was observed till September 2000 first fortnight, thereafter slight rise in value was observed in second fortnight of September 2000.

In the water sample from lower level water at site A i.e. A_2 – Minimum value was recorded in December 99 second fortnight then gradual increase in the values started till maximum value of BOD recorded in April 2000, second fortnight was 21.32 mg/L.

Mostly the surface water had higher BOD value as compared to the lower level.

AT SAMPLING STATION B

The BOD values at this sampling station show almost the same trend as found at site A. The minimum values of BOD was recorded in the month of January 2000 (first fortnight). In the water from upper level (B_1) minimum value recorded was 4.01 mg/L and in water from lower level it was 3.92 mg/L.

The maximum values at both the levels were recorded in April 2000 (first fortnight). Maximum BOD recorded in upper level water (B_1) was 19.38 mg/L and in water from lower level (B_2) it was 17.22 mg/L.

AT SAMPLING STATION C

The BOD values were slightly higher in comparison to site A and Site B specially in winter and summer months.

The minimum value of BOD was recorded in January 2000 (first fortnight) in water from both the levels i.e. (C_1) upper level and lower level (C_2). The minimum values recorded were 5.10 mg/L in upper level water sample (C_1) and 4.85 mg/L in lower level (C_2) water sample. The maximum values in water from both the levels were recorded in April 2000 (first fortnight) where

values recorded were – 29.51 mg/L in upper level (C_1)and 27.81 mg/L in lower level water (C_2).

8. FREE CARBON-DIOXIDE

Datas recorded in table VIII show that Free CO_2 concentration was usually found to be more at lower depth than in surface water. However the reverse trend was observed from May 2000 to September 2000 i.e. it was found to be more in surface water in comparison to that in water at depth.

The Carbondioxide content suddenly increased in December 99 showing first peak of rise thereafter no fixed trend of increase or decrease in carbondioxide concentration was observed. Usually higher amount of CO_2 content was observed during Rainy season except at B_2 and C_2 that is water at depth at sampling site B and C.

AT SAMPLING STATION A

Maximum values were observed in the month of September 2000 (second fortnight) in water samples from both the levels. In water sample from upper level i.e. A_1 minimum value recorded was 20 mg/L in October 99 (first fortnight) and November 99 (second fortnight) and maximum value recorded was 142 mg/L in September 2000 (second fortnight).

The free Carbondioxide content of water sample of lower depth (A_2) recorded maximum value 242 mg/l in September 2000 (2^{nd} fortnight) and the minimum value recorded was 30 mg/L in November 99 (second fortnight), January 2000 (first fortnight) and June 2000 (first fortnight).

AT SAMPLING STATION B

The minimum values recorded in water sample from upper level B_1 was 20 mg/L in October 99 (first fortnight), November (second fortnight) and March 2000 (second fortnight). Maximum value was recorded in December 99 (second fortnight) – 126 mg/L.

In water sample from lower depth i.e. B_2 the minimum value recorded was 25 mg/L in March (second fortnight) and maximum value of 136 mg/L was recorded in December 99 (first fortnight). The average seasonal value of carbondioxide content of water sample of B_2 was found to be higher in winter season.

AT SAMPLING STATION C

The maximum values observed were 138 mg/L at C_1 and 114 mg/L at C_2, recorded in August 2000 (second fortnight). The minimum value of free carbondioxide recorded in upper level water (C_1) was 20 mg/L in February 2000 (first fortnight) and from lower depth (C_2) it was 30 mg/l in January 2000 (first fortnight).

The average seasonal values in water at depth at site C too showed varied trend i.e. highest value was found in summer season and lowest value in winter season.

9. BICARBONATE CONTENT

Analytic data for Bicarbonate alkalinity revealed positive results while tests for Hydroxide and Carbonate alkalinity gave negative results.

Generally gradual rise in Bicarbonate content was observed from the beginning of the study period (October 99) to December 99 showing first peak value. Then slight decline in value was observed with sudden rise in April 2000. Usually maximum value was observed in two summer months (April 2000 and May 2000) Again from May 2000 to end of July gradual decline was observed.

AT SAMPLING STATION A

In water of this sampling station maximum value was recorded in first fortnight of April 2000 with 634.4 mg/L in water sample from upper level (A_1) and 732 mg/l in water from lower level (A_2). The minimum value was recorded in first fortnight of October 99 with 280.6 mg/L in upper level water (A_1) and 258.64 mg/L in lower level water (A_2).

AT SAMPLING STATION B

The maximum value of Bicarbonate content was recorded in different months at different water levels. In water sample from upper level i.e. B_1 it was 732 mg/L recorded in May 2000 (first fortnight) and 690.52 mg/L in November 99 (first fortnight) at lower level of water i.e. B_2.

The minimum values recorded were 185.4 mg/l and 170.8 mg/L in B_1 and B_2 respectively and were recorded in July 2000 (second fortnight).

AT SAMPLING STATION C

The maximum values obtained are 629.52 mg/L in May 2000 (first fortnight) in C_1 sample and 622.2 mg/L in April 2000 (first fortnight) in sample C_2. The minimum value of Bicarbonate content was recorded to be

229.36 mg/L in July 2000 (second fortnight) in C_1 sample and 290.36 mg/L in C_2 sample in August 2000 (first fortnight).

Average seasonal values show that the Reservoir contained maximum amount of Bicarbonate during summer season and lowest amount was found in Rainy season.

In order to have an idea of seasonal variation in Bicarbonate contents average values of different seasons were obtained from the fortnightly samplings. Datas obtained has been given ~~at the base of Table IX~~ as IX B. As per data shown, results are being given below :-

AT SAMPLING STATION A

Maximum amount of Bicarbonates were found in summer season in water of the two level, average values being 489.23 mg/L at A_1 and 485.56 mg/L at A_2. During winter season moderate amount of bicarbonate contents were found, lowest values were obtained during rainy season 373.55 mg/L at A_1 and 396.2 mg/L at A_2.

AT SAMPLING STATION B

The maximum average amount found in summer season was 534.97 mg/L at B_1 and 514.54 mg/L at B_2. Minimum average amount was observed during rainy season – 310.49 mg/L in B_1 sample and 326.96 mg/L at B_2 sampling station.

AT SAMPLING STATION C

Average maximum seasonal value was observed in summer season – 509.1 mg/L and 455.37 mg/L at C_1 and C_2 respectively. Minimum average amount

obtained in rainy season 361.57 mg/L and 348.62 mg/L at C_1 and C_2 respectively.

10. TOTAL ALKALINITY

Total Alkalinity is based on Bicarbonate alkalinity. The values of total alkalinity were high in December 99 showing first peak, thereafter since January 2000 decline was observed. There was a sudden rise in the alkalinity in April 2000 (first fortnight). Mostly the alkalinity level in all samples was at the Maximum in April 2000 or May 2000.

AT SAMPLING STATION A

Maximum amount of Alkalinity was recorded in April 2000 (first fortnight) at both the levels of water. At A_1 sampling station it was 520 mg/L and at A_2 sampling station it was 600 mg/L. The minimum value recorded was in October 99 (Second fortnight) the value being 230 mg/L at A_1 and 212 mg/L from samples at A_2.

AT SAMPLING STATION B

In water samples from this sampling station a bit different trend was observed. In samples from B_1 the maximum value was recorded in May 2000 (first fortnight) – 600 mg/L and minimum value was recorded to be 152 mg/L in July 2000 (second fortnight). In sample B_2 (of lower depth) maximum value was 522 mg/L in February 2000 (second fortnight) and minimum was 140 mg/L recorded in July 2000 (second fortnight).

At Sampling Station C

Maximum value recorded in C_1 water sample was 516 mg/L in May 2000 (first fortnight) and minimum value was 188 mg/L recorded in July 2000

(second fortnight). In sample C_2 maximum value was recorded in April 2000 (first fortnight) - 510 mg/L. Minimum value was recorded in July 2000 (second fortnight) – 192 mg/L.

11. CALCIUM CONTENT

The values of Calcium content in water samples from near the surface and from certain depth showed varied trends. No definate trend of comparative values of two levels was observed. In samples from sampling station A during the study period Calcium content was usually found to be more at upper level except in October 99 and December 99. At Sampling station 'B' during maximum period of study the Calcium content was found to be more in water near surface since February 2000 (second fortnight). Till February 2000 it was comparatively more in water at certain depth than in water at surface level.

At sampling station C too usually Calcium Content was more in surface water except December 99 (first fortnight), January 2000 and February 2000 first fortnight when reverse was observed.

Average seasonal value was higher in winter.

AT SAMPLING STATION A

In A_1 water sample maximum amount of Calcium found was 129.52 mg/L in June 2000 (first fortnight) and minimum amount was 35.32 mg/L recorded in May 2000 (first fortnight). In A_2 sample maximum value recorded was 147.18 mg/L in October 99 (first fortnight) and minimum value was 25.23 mg/L recorded in April 2000 (second fortnight).

AT SAMPLING STATION B

In B_1 water sample of upper level maximum value was recorded in May 2000 (first fortnight) 153.07 mg/L and minimum value was recorded in July 2000 (second fortnight) – 60.56 mg/L.

In B_2 water sample from lower level the lowest amount of Calcium was recorded – 12.62 mg/l in September 2000 (second fortnight). Maximum value recorded in this sample was 147.18 mg/L in January 2000 (first fortnight).

AT SAMPLING STATION C

In water samples from this sampling station very little variation was observed in Calcium content of water at two levels. In sample C_1 maximum value observed was 158.96 mg/L in December 99 (second fortnight) and minimum value was 68.97 mg/L recorded in July (second fortnight).

In sample C_2 the maximum value was recorded in the same month i.e. December 99 (first fortnight) – 154-75 mg/L and minimum value was 21.03 mg/L recorded in September 2000 (second fortnight).

12. MAGNESIUM

Usually maximum amount in winter months was found at all sites (November and December 99). The value started declining from June 2000 to August 2000. The Magnesium content was comparatively low in the later half of study period.

AT SAMPLING STATION A

In sample A_1 maximum value recorded was 47.83 mg/L in November 99 (first fortnight) and minimum was 3.32 mg/L in June 2000 (second fortnight).

In sample A_2 maximum value observed was 55.49 mg/L in December 99 (first fortnight) and minimum was 4.05 mg/L in October 99 (first fortnight).

AT SAMPLING STATION B

Maximum values were recorded in both water samples B_1 and B_2 in December 99 (first fortnight). Value at B_1 (surface level) was 51.80 mg/L and in B_2 was 65.05 mg/L. Minimum value recorded were 3.42 mg/L in B_1 in August 2000 (second fortnight) and 3.46 mg/L in B_2 in December 99 (second fortnight).

AT SAMPLING STATION C

Maximum values were recorded in December 99. In water from upper level C_1 the maximum value of Magnesium content recorded was 57.62 mg/L and in C_2, water from lower level it was 68.14 mg/L. The minimum values were recorded in June 2000 (second fortnight) in C_1 and C_2 samples and were 0.49 mg/L and 1.70 mg/L respectively.

13. TOTAL HARDNESS

It was observed that mostly the water at surface level was usually hard for maximum period during the study period, except in October 99 (second fortnight) & December 99 at site A; in October 99 (second fortnight) Nov. 99 (first fortnight), December 99, January 2000 and February 2000 at Site B; in November 99, December 99 and January 2000 at site C when reverse was observed i.e. higher value of Total hardness was observed in water sample at lower level.

At site A and B at both levels and at C in lower level, the average seasonal value was higher in winter season and mostly lowest value was observed in rainy season.

AT SAMPLING STATION A

In the water from upper level (A_1) maximum value observed was 358 mg/L in June 2000 (second fortnight) and minimum value was 152 mg/L in May 2000 (first fortnight). The water sample from lower depth (A_2) showed a different trend as maximum value was recorded in October 99 (first fortnight) – 384 mg/L. The minimum value was recorded in the same month as in upper level water, in May 2000 (first fortnight) – 122 mg/L.

AT SAMPLING STATION B

The maximum value was recorded in May 2000 (first fortnight) – 414 mg/L in water of upper level (B_1) and 402 mg/L in December 99 (first fortnight) in water of lower depth (B_2).

The minimum values were recorded in different months at the two levels. In sample from B_1 level it was recorded to be 194 mg/L in July 2000 (2^{nd} fortnight) and in B_2 it was 102 mg/L in April 2000 (first fortnight).

AT SAMPLING STATION C

The maximum values were recorded in the same month in water from both the levels. It was recorded to be 432 mg/L in C_1 (upper level water) and 438 mg/L in C_2 (lower level water) in December 99 (second fortnight).

The minimum value recorded in upper level water (C_1) was 198 mg/L and in lower level water it was 146 mg/L observed in two months – April 2000 (first fortnight) and August 2000 (second fortnight).

TABLE II A. MONTHLY VARIATION IN WATER TEMPERATURE AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct.99 I	28	26	28	25	31	30
II	26	25	26	25	28	25
Nov.99 I	22	21	23	22	24	23
II	22	22	22	21	24	21
Dec.99 I	21	18	23	22	19	18
II	18	17	21	19	18	17
Jan.2000 I	17	16	18	17	17	16
II	18	17	18	18	18	15
Feb.2000 I	19	18	19	19	19	17
II	19	17	20	18	19	17
March 2000I	20	19	21	19	19	18
II	23	22	24	22	23	21
April 2000 I	25	20	27	20	25	20
II	26	22	29	27	24	21
May.2000 I	23	22	24	22	22	21
II	26	24	27	26	26	23
June.2000 I	24	23	27	26	25	24
II	28	26	28	26	26	24
July.2000 I	29	27	30	29	28	26
II	26	24	28	26	25	24
Aug.2000 I	25	23	25	24	24	23
II	24	23	24	24	23	22
Sep.2000 I	27	26	28	27	27	30
II	28	26	28	26	25	27

Fig.IIA1-Monthly Variation in Water Temperature At Different Sampling Stations

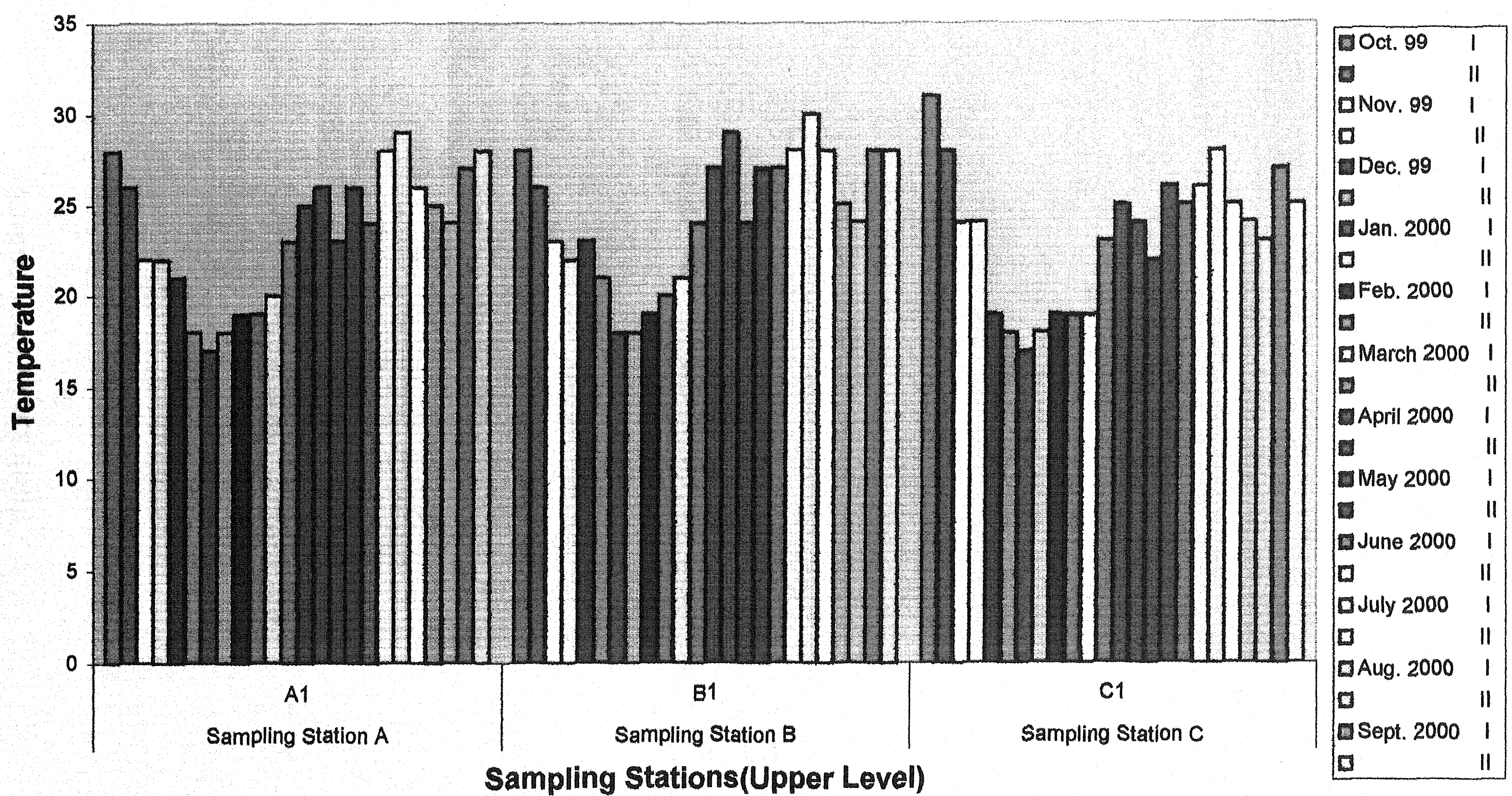


Fig.II A2-Monthly Variation in Water Temperature

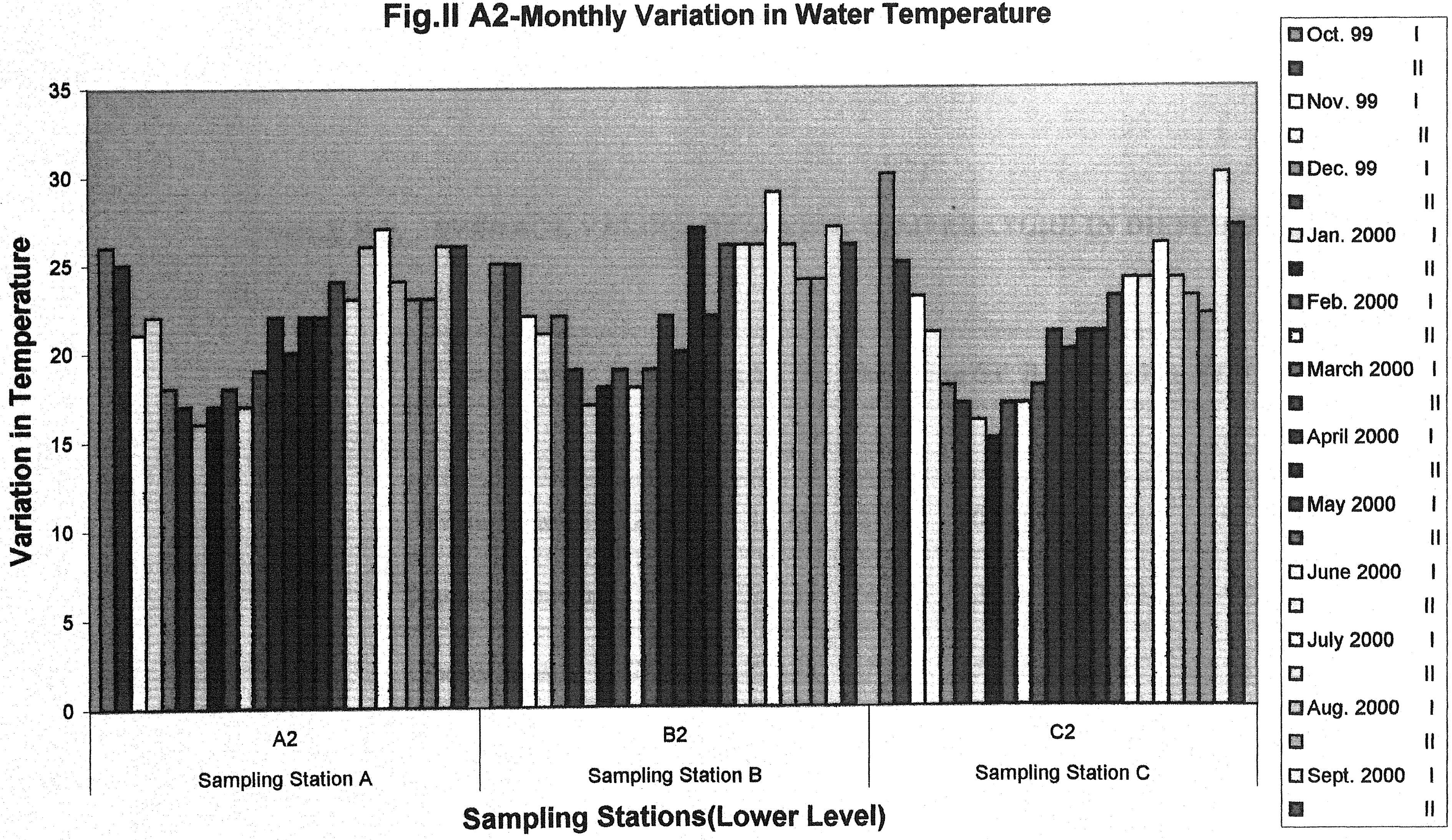


TABLE II B. AVERAGE VALUES OF WATER TEMPERATURE IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	20.375	19.25	21.25	20.375	20.875	19
Summer Season	23.25	21.125	24.875	22.5	22.875	20.625
Rainy Season	26.875	25.125	27.375	25.875	26.125	25.75

Fig. IIB - Average Values of Water Temperature in Different Seasons

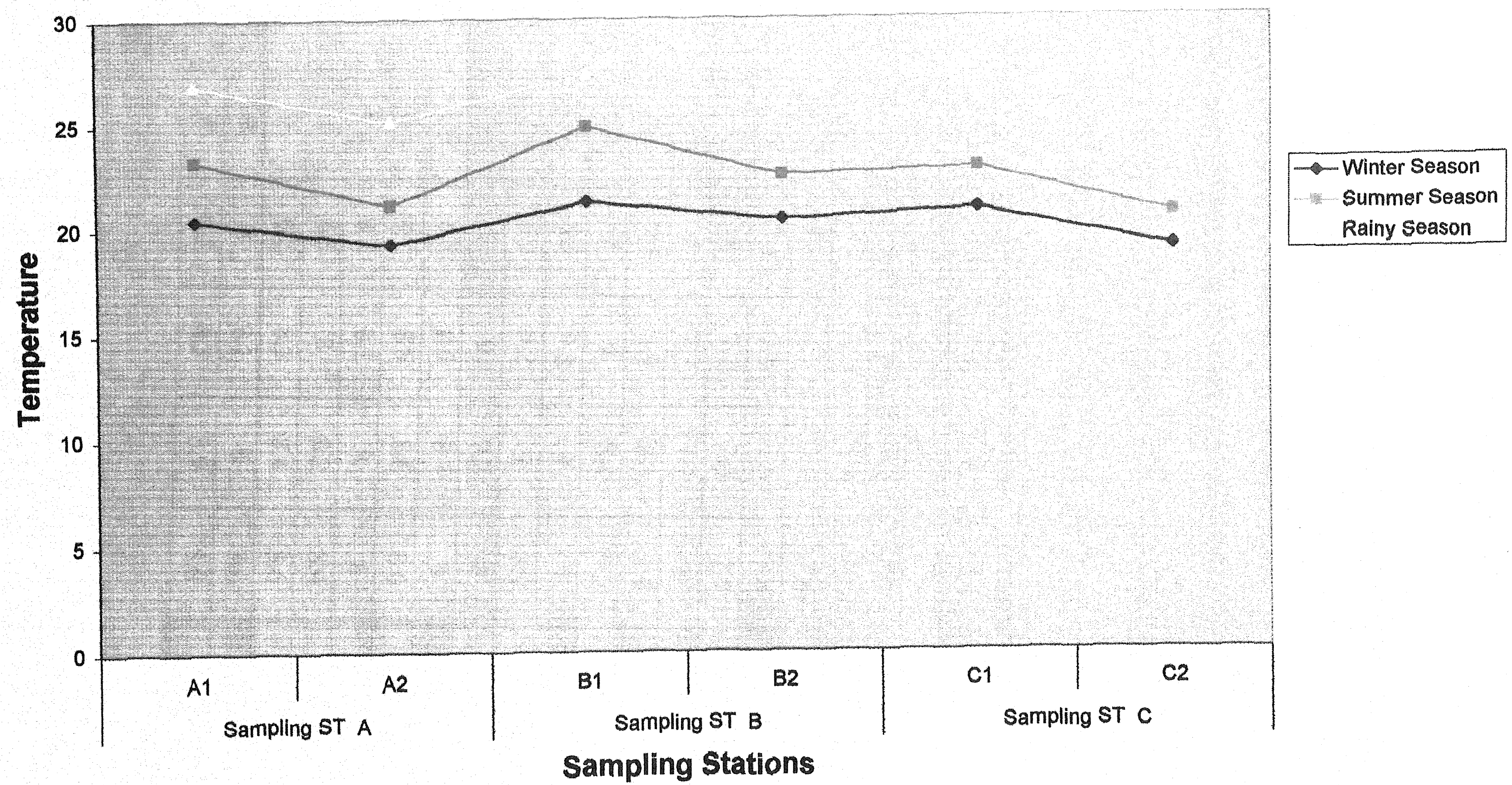


TABLE III A. MONTHLY VARIATION IN pH AT DIFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST. B		Sampling ST. C	
	A1	A2	B1	B2	C1	C2
Oct. 99 I	7.5	7.2	7.9	7	7.9	7.4
II	7.6	7.3	7.8	7.8	7.9	7.6
Nov. 99 I	7.4	7.2	8	8.1	7.8	7.4
II	7.4	7.2	8.1	8.5	7.8	7.2
Dec. 99 I	7.5	7.3	7.8	8	7.5	7.3
II	7.6	7.4	7.6	7.8	7.6	7
Jan.2000 I	7.4	7.1	7.4	7.3	7.1	7.3
II	7.4	7.2	7 .5	7.4	7.2	7.8
Feb.2000 I	7.4	7.1	7.3	7.2	7.4	7.5
II	7.6	7.4	7.8	7.6	7.8	7.6
Mar. 2000 I	8	8	7.7	7.3	7.5	7.6
II	8.5	8	7.7	7.7	8	8.9
Apr. 2000 I	9.2	9.3	8.9	8.3	8.9	8
II	9.1	9	9	8.4	9.2	7.8
May 2000 I	9	8.9	9.2	9	9	8.8
II	9	8.9	9.2	9	8.9	8
June 2000 I	9	9	9	9.2	8	8.9
II	8.9	8.7	8.9	8.7	9	8.5
July 2000 I	8.5	8.7	8.5	8.6	8.6	8.4
II	8.5	8.7	8.1	8	8	8.2
Aug. 2000 I	8	8.3	8	8.2	8.4	8
II	8	8.2	8.3	8.4	8.6	8.8
Sept. 2000 I	8	8	8.1	8	8.8	8.8
II	8	8.5	8.3	8.9	8.8	9

Fig. III A1- Monthly Variation in pH At Different Sampling Stations

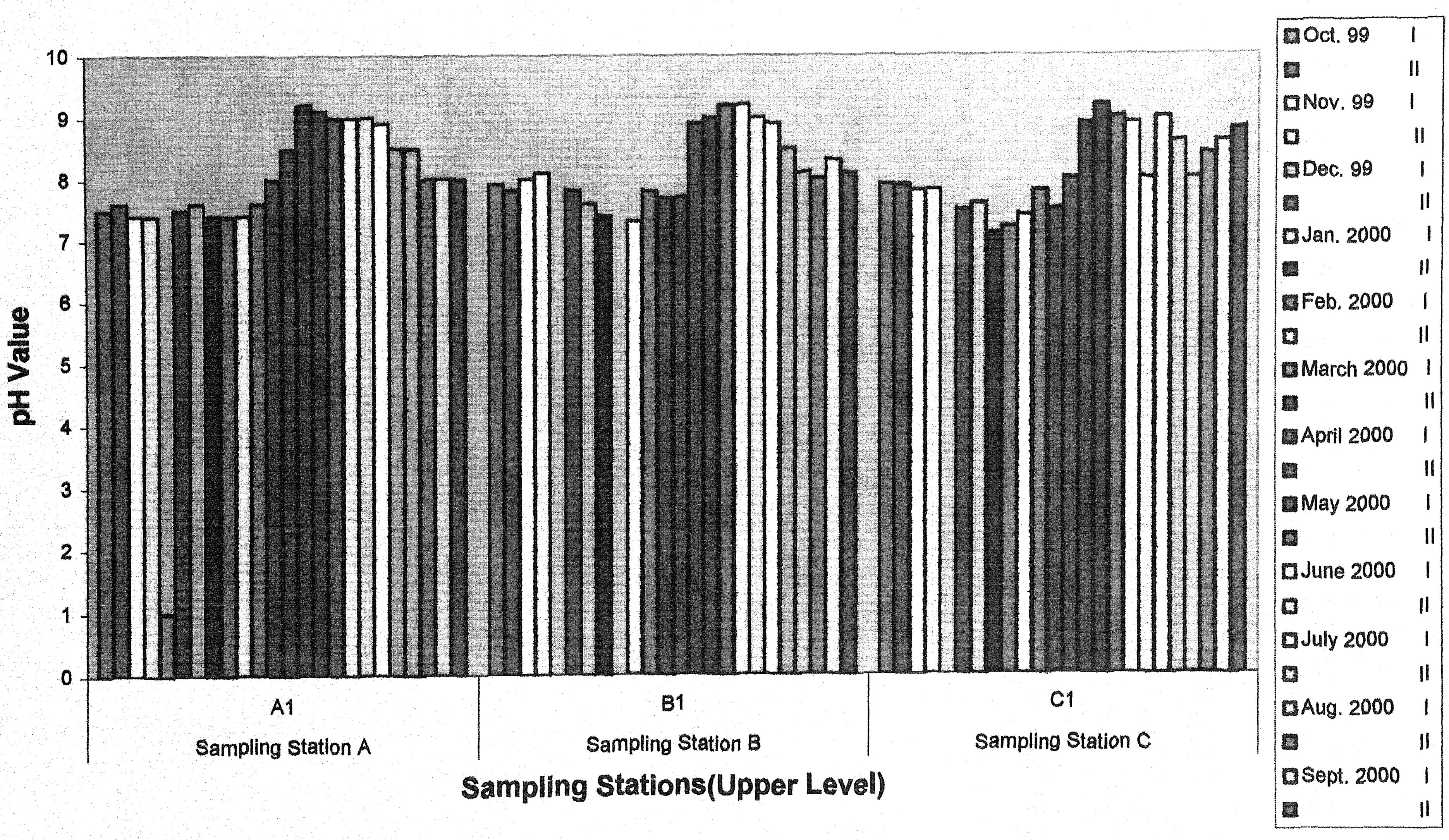


Fig.III A2-Monthly Variation In ph At Different Sampling Stations

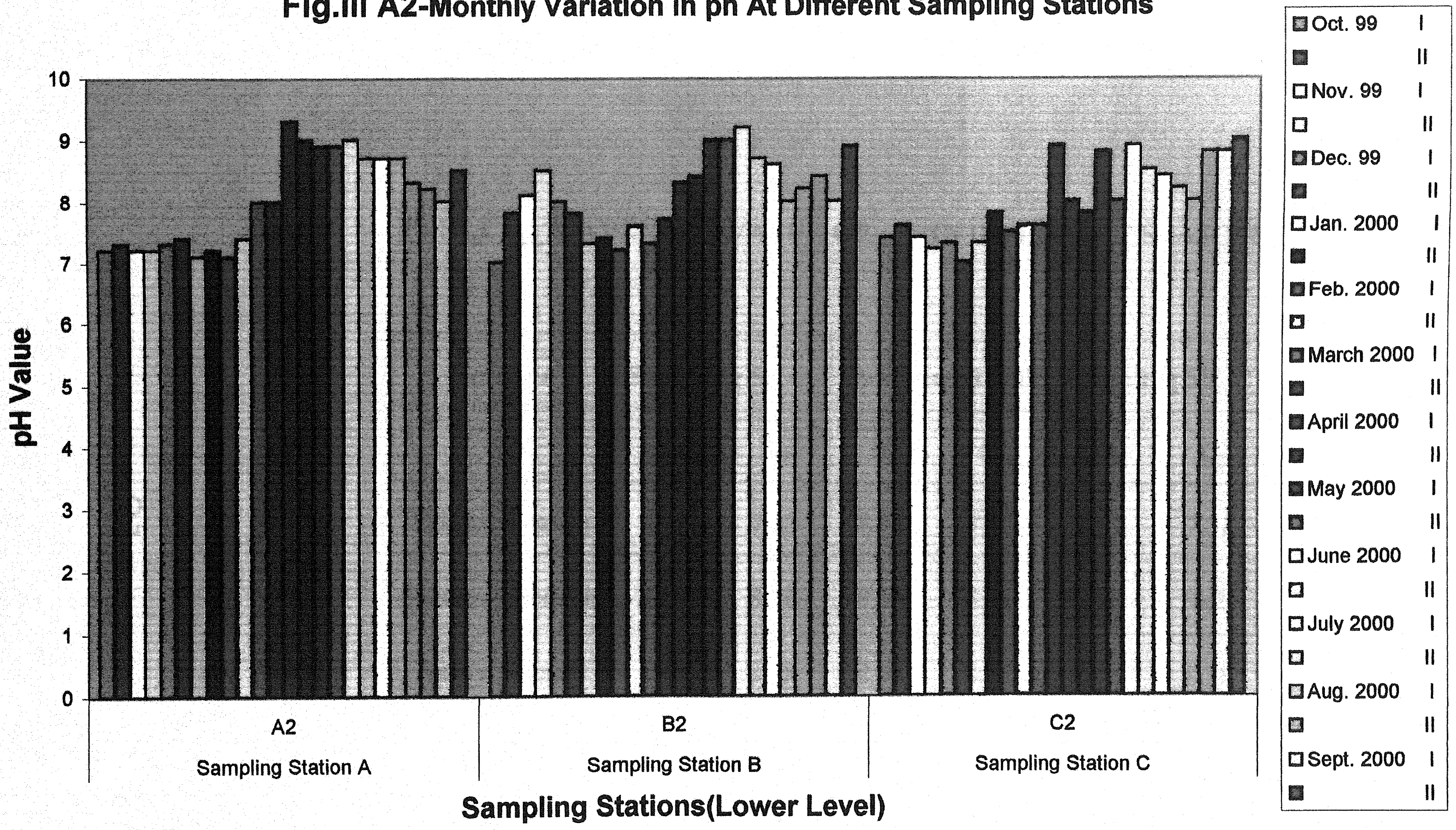


TABLE III B. AVERAGE VALUE OF pH IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	7.46	7.23	7.68	7.76	7.53	7.38
Summer Season	8.67	8.56	8.56	8.31	8.41	8.2
Rainy Season	8.17	8.28	8.26	8.22	8.51	8.38

Fig.III B Average Seasonal Value of pH

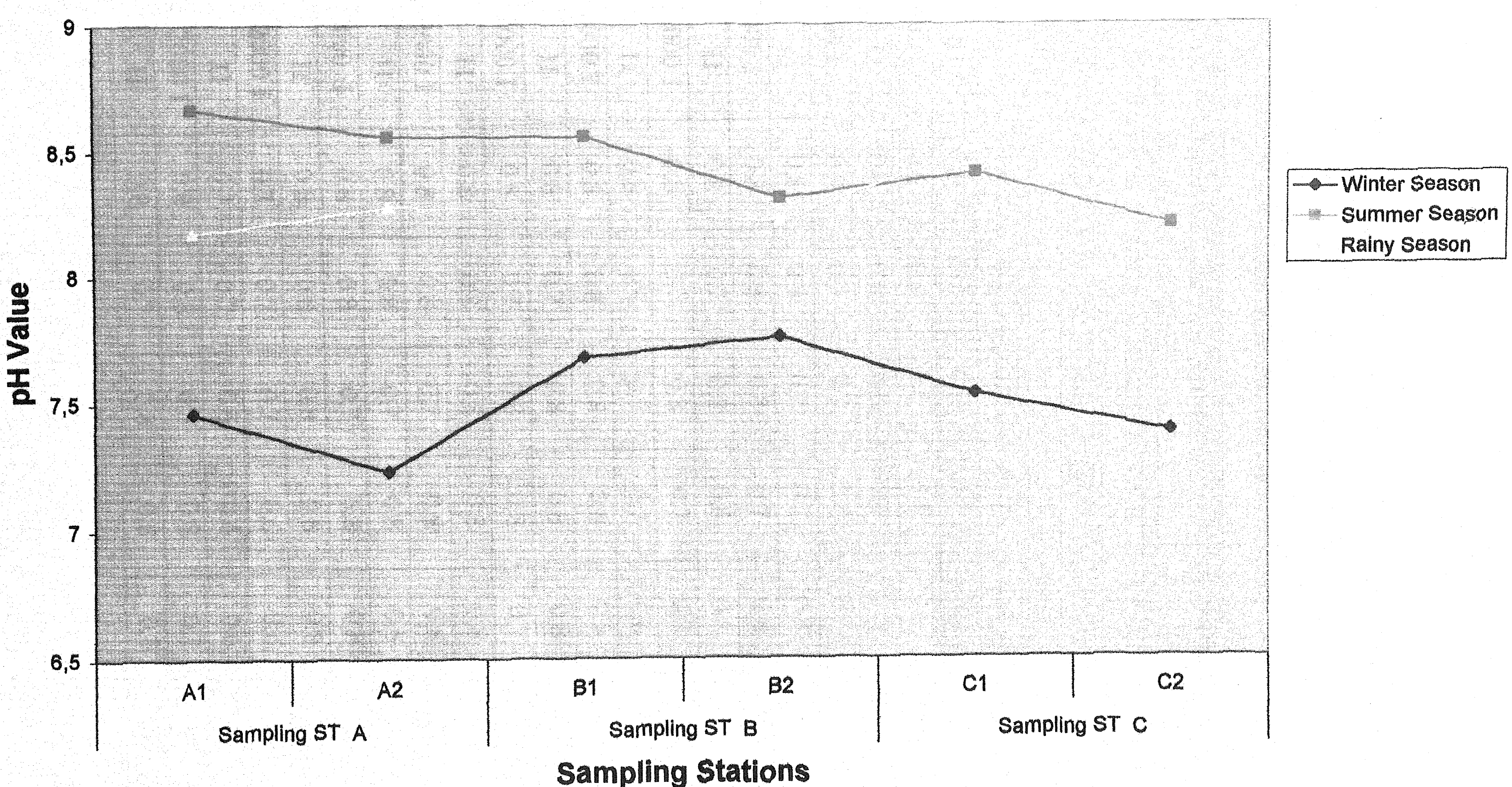


TABLE IV A. MONTHLY VARIATION IN CONDUCTIVITY AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	0.8	0.8	0.8	0.7	0.7	0.7
II	0.7	0.8	0.8	0.8	0.7	0.7
Nov. 99 I	0.8	0.8	0.7	0.7	0.7	0.7
II	0.8	0.7	0.7	0.7	0.8	0.7
Dec. 99 I	0.6	0.6	0.6	0.4	0.5	0.4
II	0.6	0.6	0.6	0.4	0.5	0.4
Jan.2000 I	0.8	0.7	0.7	0.7	0.7	0.7
II	0.8	0.8	0.7	0.7	0.8	0.8
Feb.2000 I	0.8	0.8	0.8	0.7	0.8	0.8
II	0.8	0.7	0.8	0.8	0.8	0.7
Mar. 2000 I	0.8	0.7	0.8	0.7	0.7	0.7
II	0.8	0.8	0.7	0.7	0.6	0.7
Apr. 2000 I	0.8	0.8	0.8	0.8	0.8	0.7
II	0.8	0.7	0.8	0.8	0.8	0.7
May 2000 I	0.8	0.7	0.8	0.8	0.7	0.7
II	0.8	0.8	0.8	0.8	0.8	0.7
June 2000 I	0.8	0.8	0.7	0.8	0.8	0.8
II	0.8	0.8	0.7	0.8	0.8	0.8
July 2000 I	0.8	0.8	0.7	0.8	0.8	0.7
II	0.8	0.8	0.8	0.8	0.8	0.7
Aug. 2000 I	0.7	0.7	0.7	0.6	0.6	0.6
II	0.7	0.7	0.6	0.6	0.6	0.6
Sept. 2000 I	0.8	0.8	0.8	0.8	0.7	0.8
II	0.8	0.7	0.8	0.8	0.8	0.8

Fig.IV A1-Monthly Variation In Conductivity

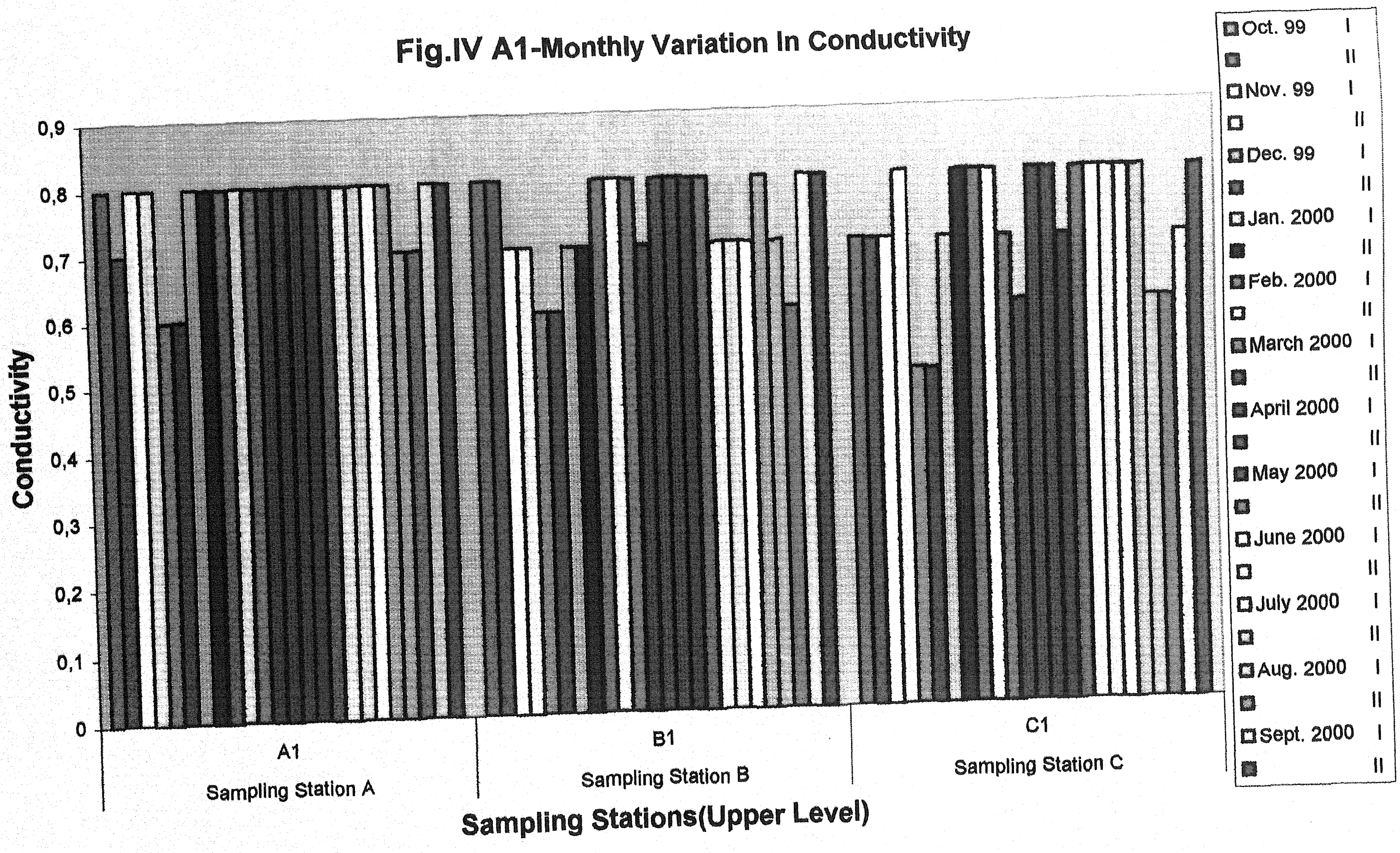


Fig . IV A2- Monthly Variation In Conductivity

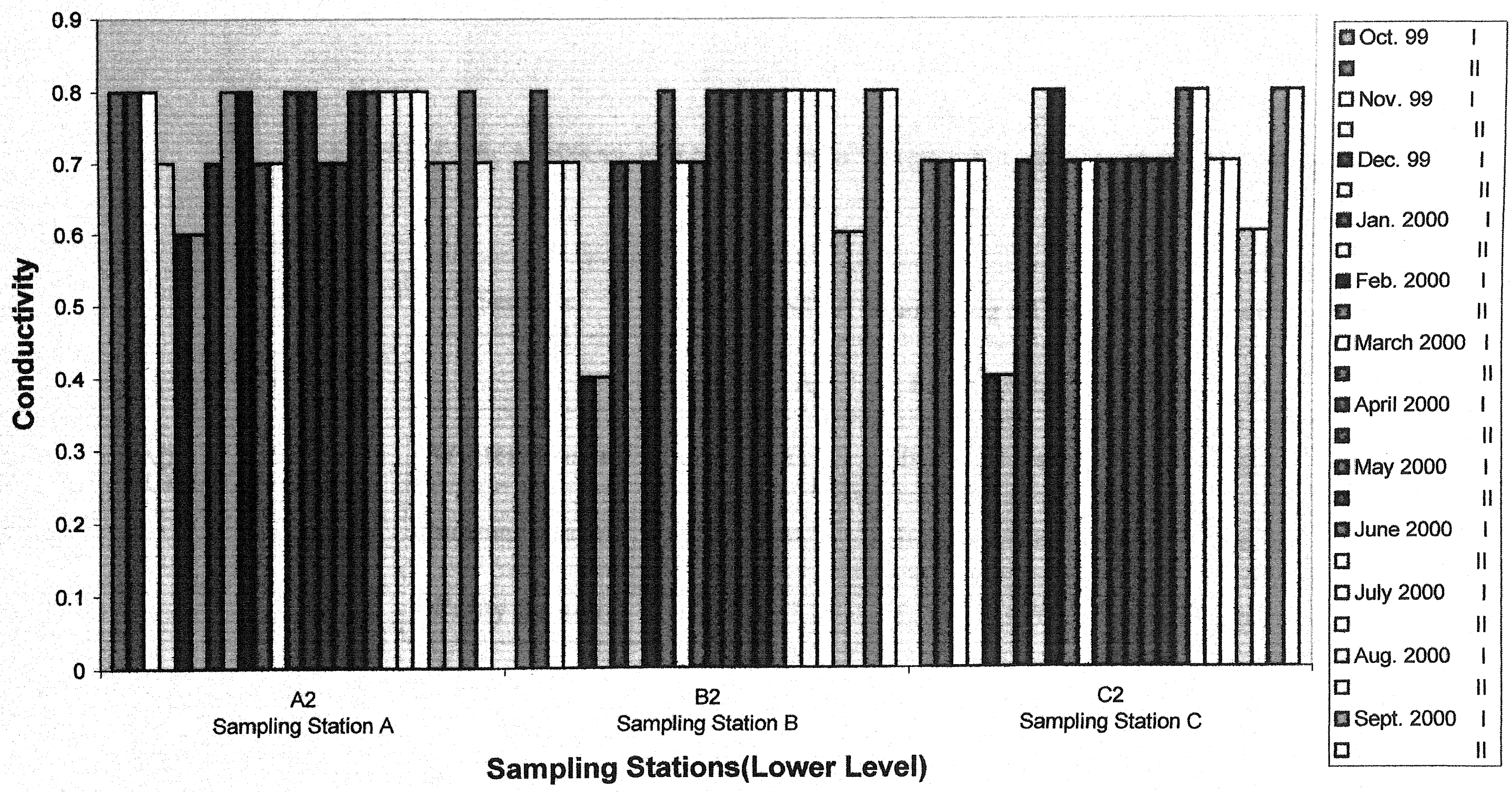


TABLE IV B. AVERAGE VALUES OF CONDUCTIVITY IN DIFFERENT SEASON

S

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	0.7	0.7	0.7	0.6	0.6	0.6
Summer Season	0.8	0.7	0.7	0.8	0.7	0.7
Rainy Season	0.8	0.7	0.7	0.7	0.7	0.7

Fig. IVB-Averege Value Of Conductivity in Different Seasons

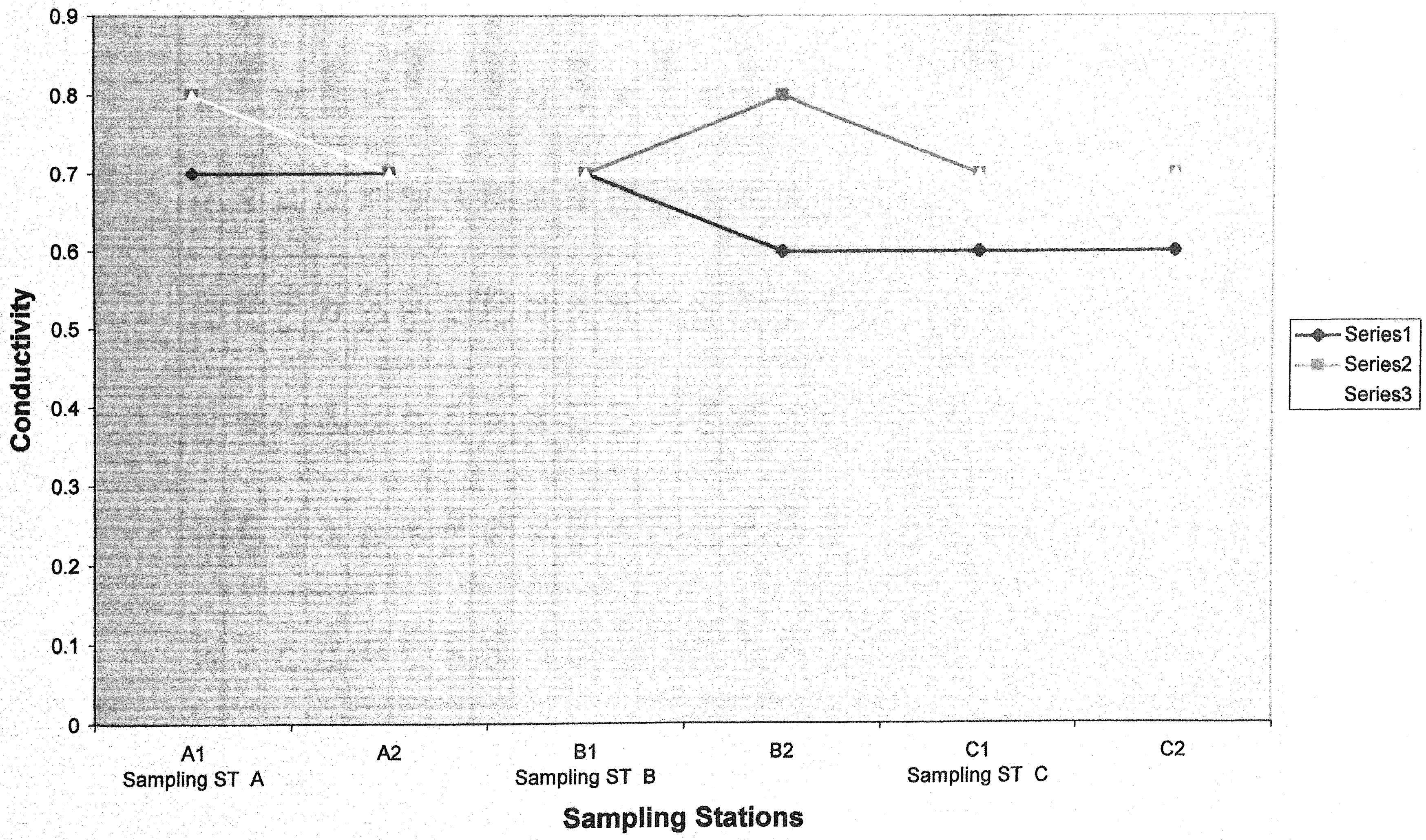


TABLE V A. **MONTHLY VARIATION IN CHLORIDE CONTENT mg/L AT DIFFERENT SAMPLING STATIONS**

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	14	10.5	4.5	3.99	9.99	7.49
II	78	66	86	63.5	69	61
Nov. 99 I	74	66	67	49	58.5	50
II	87	82.5	65	60	65	56
Dec. 99 I	126	118	163	126	125	121
II	134	119	104	66.5	143	112
Jan.2000 I	47	37.5	62	52.5	62.5	48.5
II	35	42.5	37	45	37.5	50
Feb.2000 I	49	54	54	80.5	61.5	71
II	53	75.5	72	90.5	68	75
Mar. 2000 I	37	63.5	76	93.5	64.5	55.5
II	37	72.5	987	112	77.5	52.5
Apr. 2000 I	110	80	97	87.5	82.5	62.5
II	113	87	111	80	86.5	69
May 2000 I	94	85	118	83.5	77.5	72.5
II	78	75	98	74	77	70
June 2000 I	65	62.5	78	64	76.5	67.5
II	75	116	109	98.5	100	144
July 2000 I	60	63.5	45	49	52.5	66
II	51	45.5	15	22	15	23
Aug. 2000 I	53	62	42	49	42.5	49
II	51	76.5	67	74.5	68.5	73.5
Sept. 2000 I	90	82.5	84	80.5	113	88.5
II	139	99.5	128	127	131	112

Fig.VA1-Monthly Variation in Chloride Content mg/L At Different Sampling Station

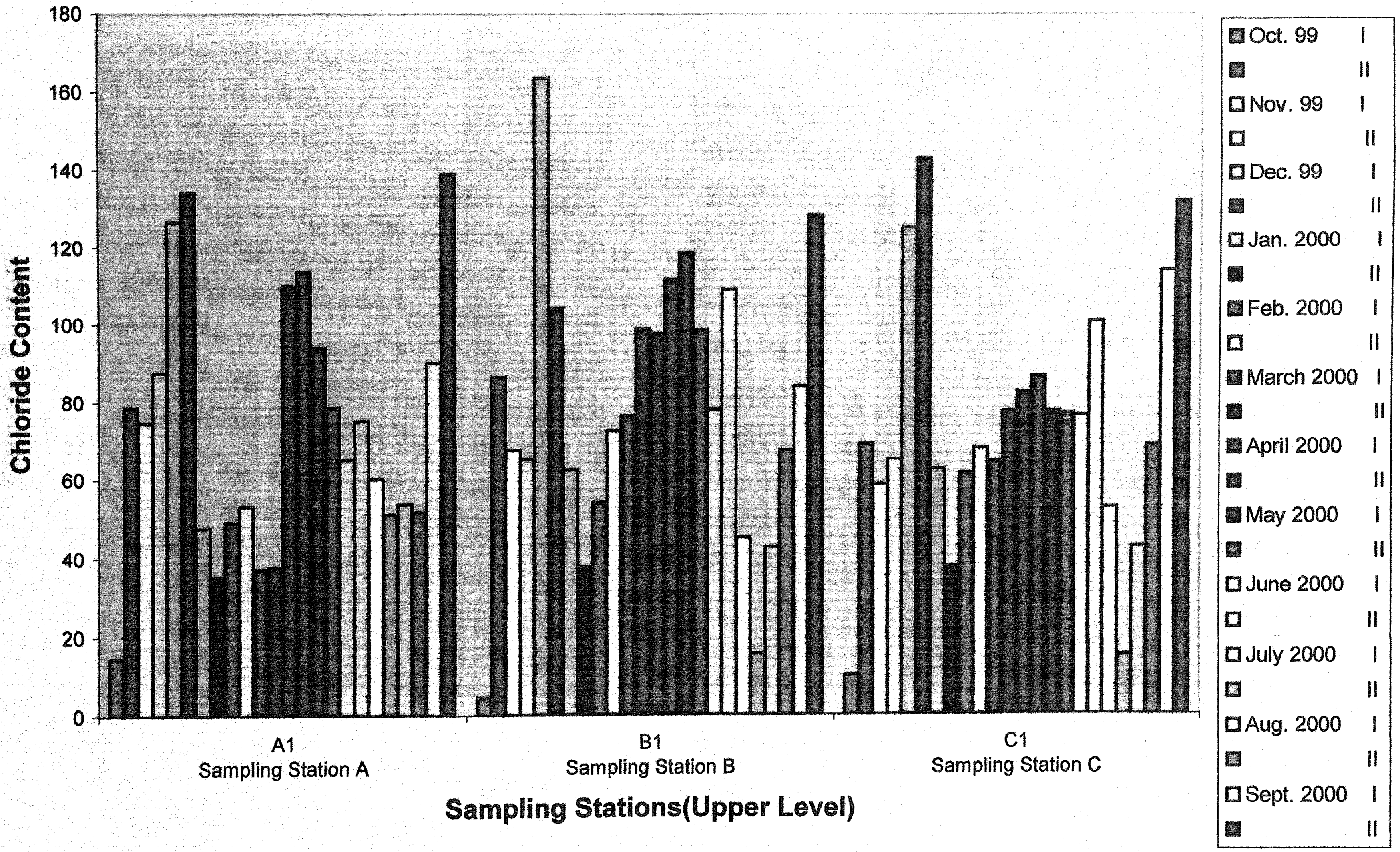


Fig.VA2-Monthly Variation In Chloride Content mg/L At Different Sampling Stations

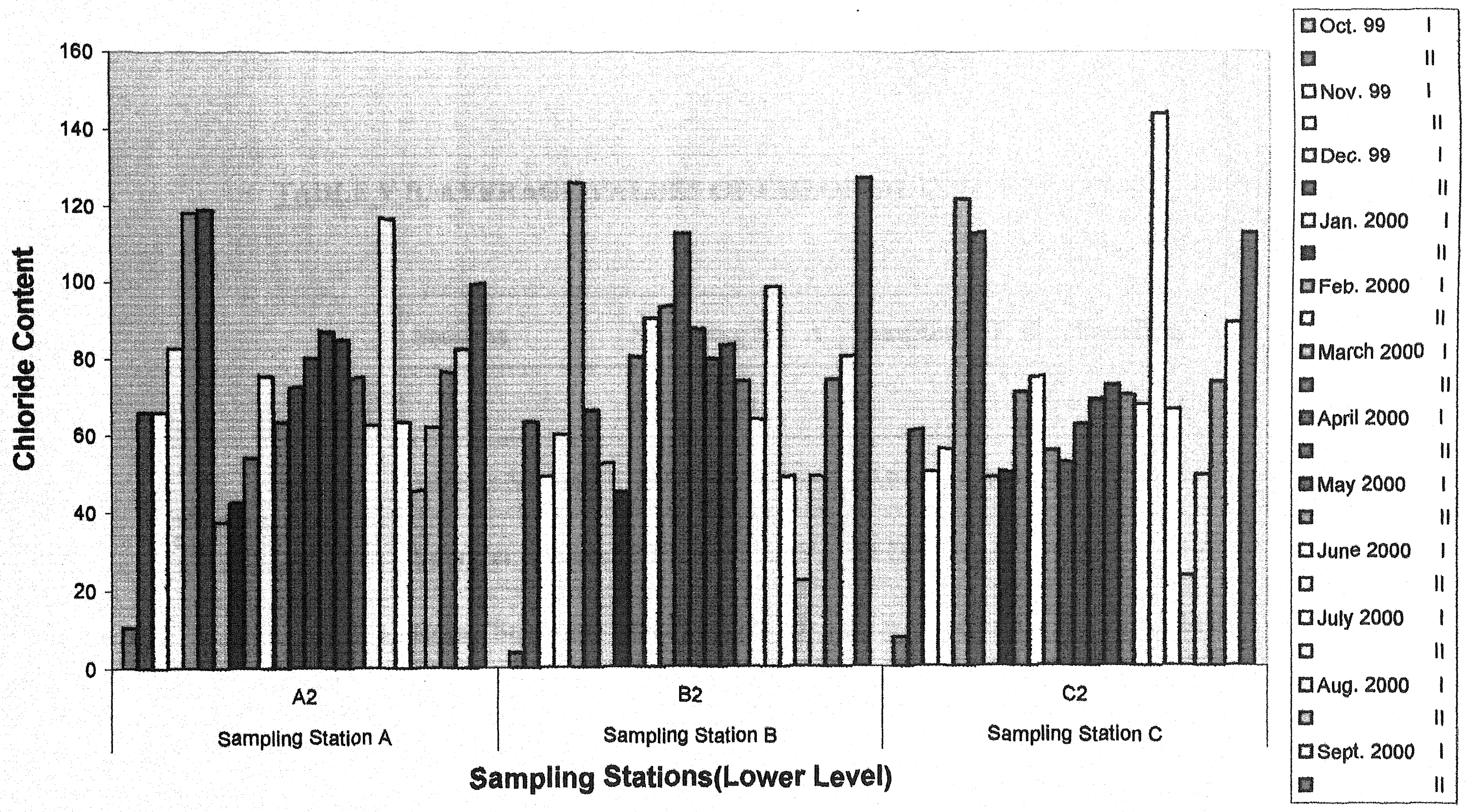


TABLE V B. AVERAGE VALUES OF CHLORIDE CONTENT IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	79.03	73.16	80.03	67.85	77.72	71.28
Summer Season	73.54	75.10	93.78	85.66	76.23	65.54
Rainy Season	66.79	69.53	61.97	63.04	66.72	70.41

Fig.VB-Average Value Of Chloride Content In Different Seasons

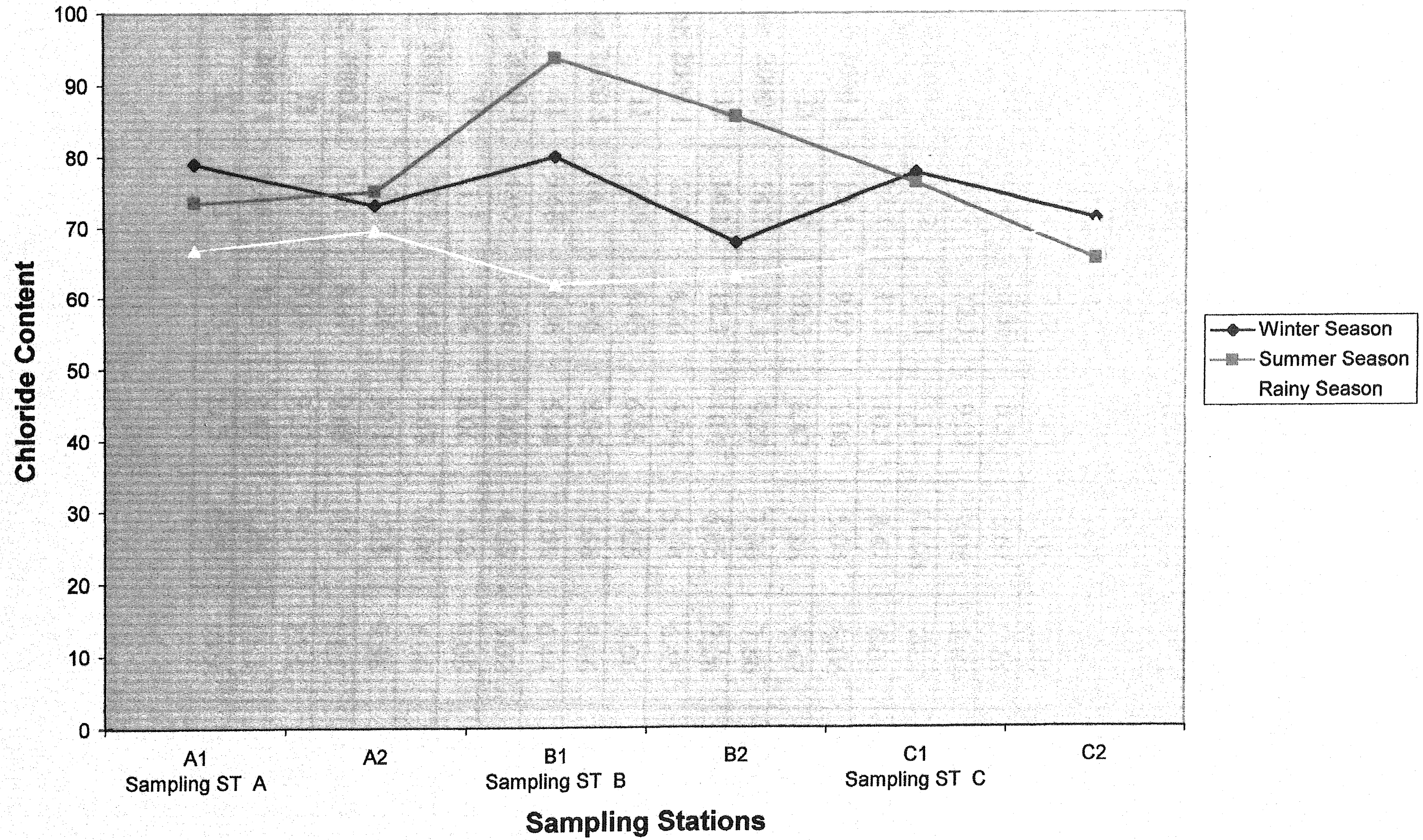


TABLE VI A MONTHLY VARIATION IN DISSOLVED OXYGEN. Mg/L AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	24.2	22.2	20.2	16.12	20.2	17.5
II	18.2	12.2	40.3	36.29	34.3	31.3
Nov. 99 I	15.3	8.67	17.5	12.7	19	10.7
II	13.1	7.06	14.1	7.06	7.06	6.05
Dec. 99 I	6.45	5.85	8.27	5.67	7.86	6.05
II	19.7	12.1	9.27	9.08	8.06	6.45
Jan.2000 I	16.2	11.1	13.1	11.08	20.2	17.1
II	12.1	11.1	10.1	8.47	6.05	4.64
Feb.2000 I	13.1	9.07	7.06	5.04	8.06	6.05
II	13.9	10.3	8.47	7.86	8.47	6.25
Mar. 2000 I	14.1	11.3	9.27	7.06	7.86	6.25
II	14.1	12.1	10.1	6.05	7.06	6.05
Apr. 2000 I	6.05	8.06	3.04	5.04	6.45	8.06
II	9.28	6.45	6.65	6.05	8.06	8.06
May 2000 I	14.1	7.06	8.06	7.66	8.66	8.46
II	9.68	8.06	5.44	5.05	6.44	6.26
June 2000 I	4.03	7.06	3.02	4.03	3.02	6.05
II	11.1	5.04	8.06	7.68	9.05	8.06
July 2000 I	10.7	6.45	9.68	10.09	8.06	7.86
II	10.1	7.86	12.1	12.5	9.88	7.66
Aug. 2000 I	9.68	8.87	9.68	9.09	11.1	8.87
II	9.07	9.08	9.27	9.27	12.1	9.88
Sept. 2000 I	9.48	10.5	8.47	6.85	11.3	10.5
II	12.3	6.25	11.5	6.45	13.9	10.5

Fig.VIA1-Monthly Variation in Dissolved Oxygen Mg/L At Different Sampling Stations

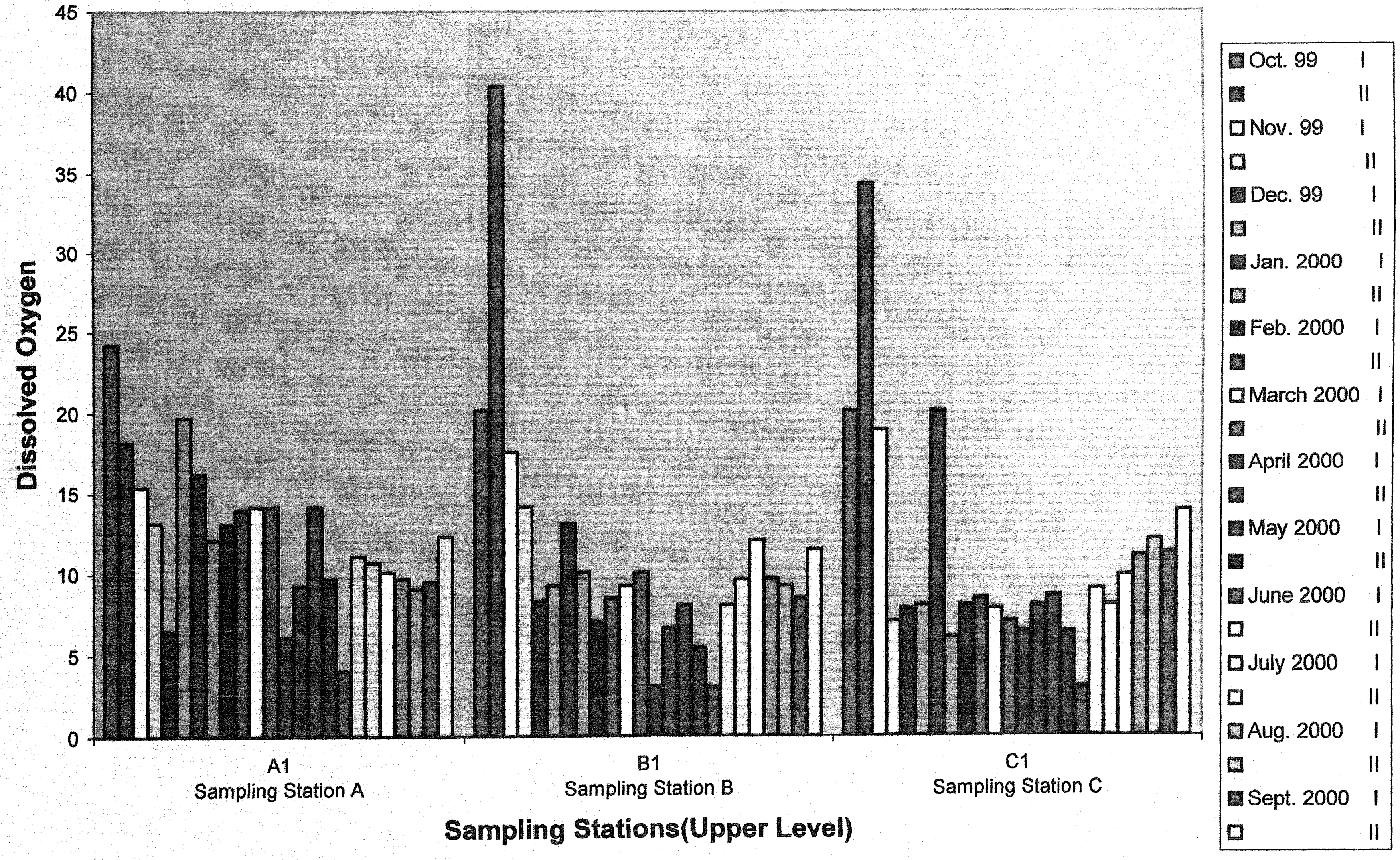


Fig.VI A2-Monthly Variation in Dissolved Oxygen Mg/L At Different Sampling Stations

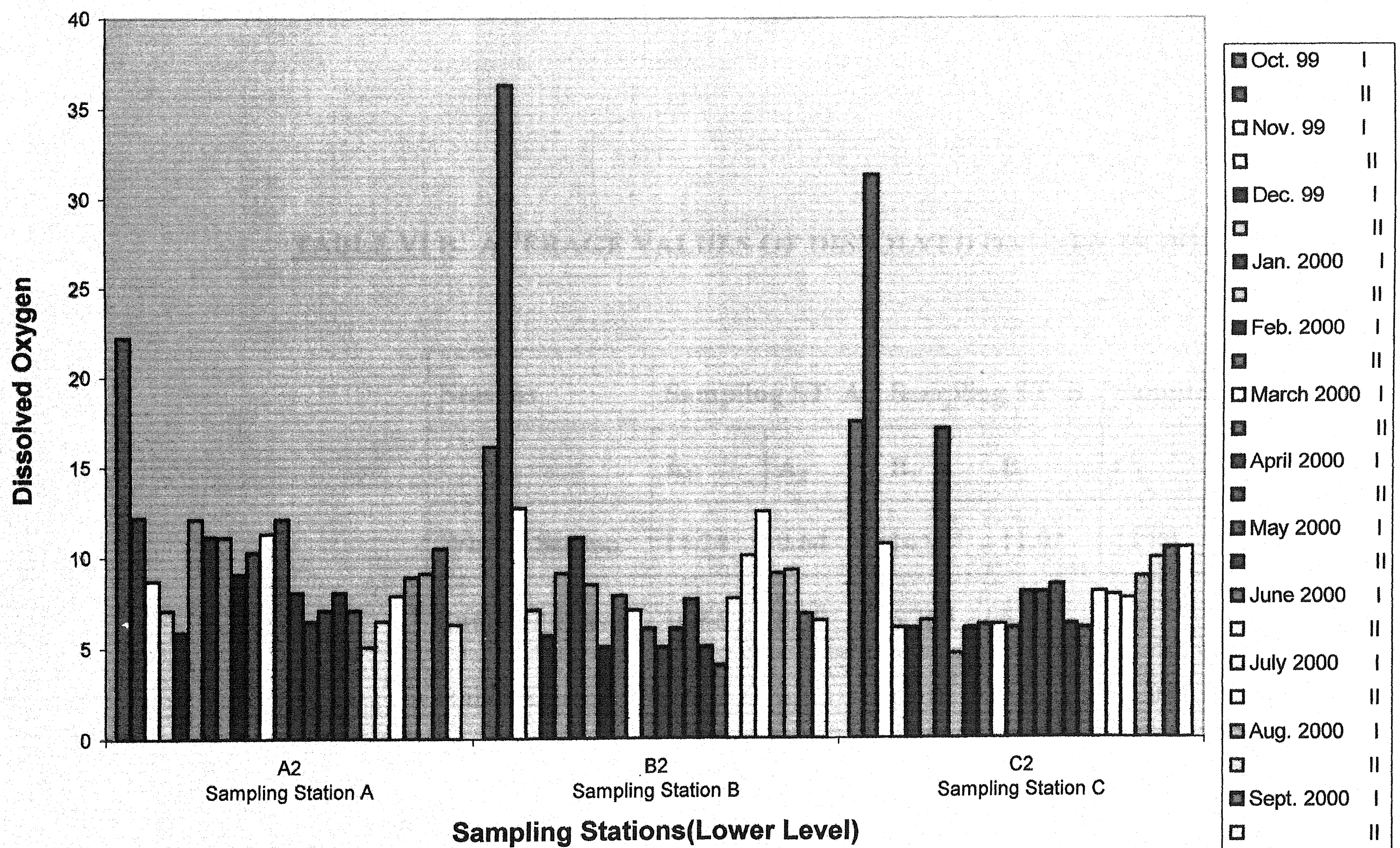


TABLE VI B. AVERAGE VALUES OF DISSOLVED OXYGEN IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	14.24	9.64	14.96	11.92	13.80	11.04
Summer Season	10.66	8.79	6.75	6.1	7.0	6.93
Rainy Season	12.06	9.52	11.11	9.75	11.94	10.10

Fig.VIB-Average Value Of Dissolved Oxygen In Different Seasons

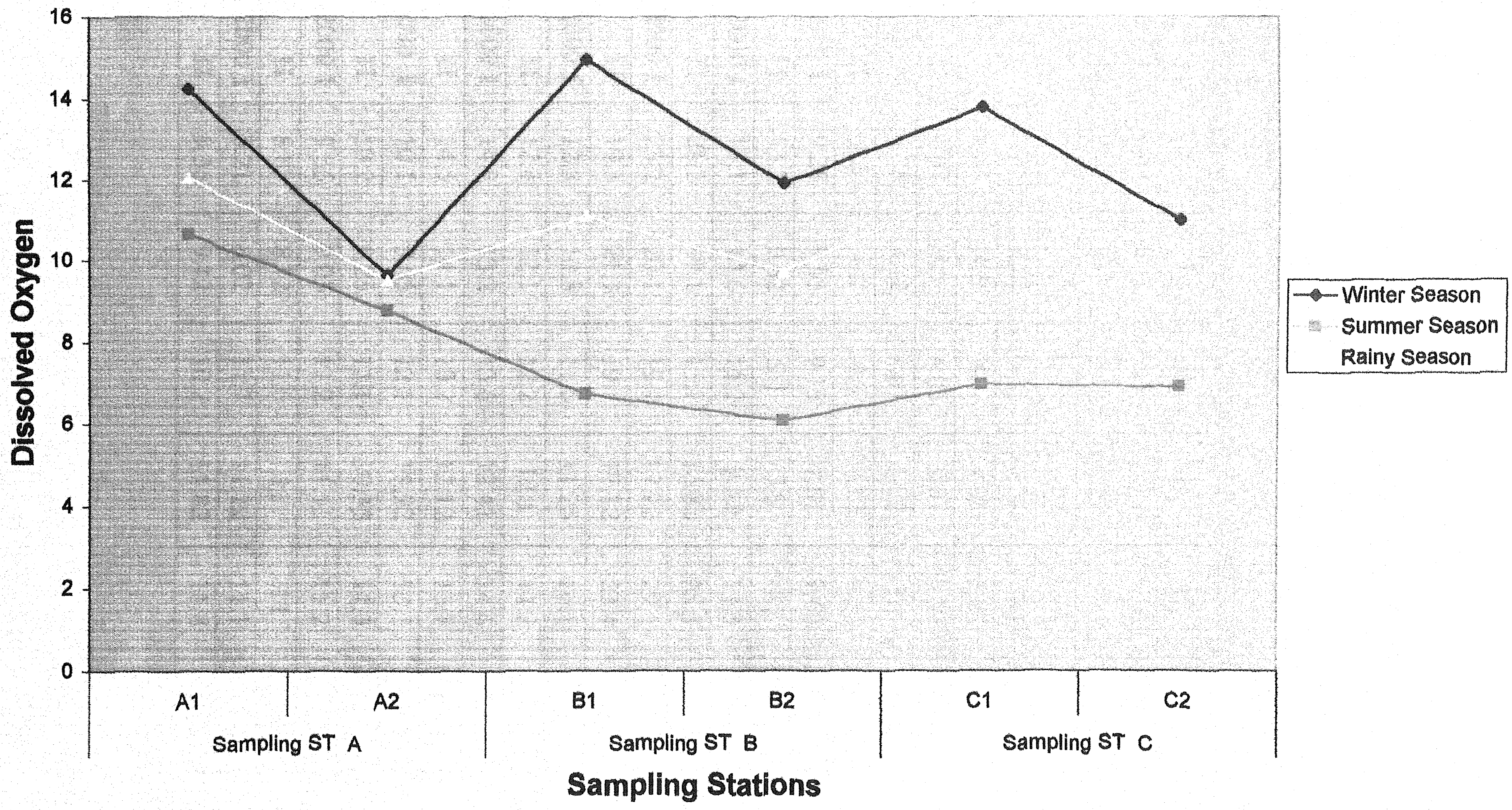


TABLE VII A MONTHLY VARIATION IN BIOCHEMICAL OXYGEN DEMAND (BOD mg/L) AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	6.84	6.12	6.5	6.11	8.31	8.5
II	6.25	6.1	6.11	6.05	8.25	8.01
Nov. 99 I	6.2	6.15	6.19	6.25	8.67	8.22
II	5.85	6.25	6.25	6.31	7.01	8.31
Dec. 99 I	4.86	4.5	4.1	4.07	6.82	6.12
II	4.62	4.1	4.05	4.01	6.32	6.05
Jan.2000 I	4.18	4.12	4.01	3.92	5.1	4.85
II	4.3	4.2	4.3	4.12	5.55	5.01
Feb.2000 I	9.28	9.55	9.15	7.81	9.62	7.32
II	13.2	9.32	9.1	7.5	9.2	7.11
Mar. 2000 I	15.1	13.6	11.2	9.32	13.3	8.83
II	21.2	19.1	15.1	15.85	25.3	23.3
Apr. 2000 I	23.2	20.1	19.4	17.22	29.5	27.8
II	19.3	21.3	19.1	17.12	23.4	20.1
May 2000 I	12.8	12.8	11.6	11.25	16.1	15.4
II	12.4	12.1	12.2	12.1	14.2	12
June 2000 I	14.8	13.2	13.6	12.41	14.6	12.8
II	14.5	14.1	13.2	12.12	13.7	11.7
July 2000 I	10.1	9.65	12.1	11.92	13.3	10.5
II	10.2	9.25	11.1	10.33	11.3	11
Aug. 2000 I	9.36	9.05	11.2	11.11	11.2	10.8
II	8.85	8.12	11.6	11	11	10
Sept. 2000 I	8.21	8.02	11.7	11.12	11.1	10.5
II	9.36	9.12	10.2	11.82	11.8	11.6

Fig.VII A1-Monthly Variation In Biochemical Oxygen Demand Mg/L At Different Sampling Stations

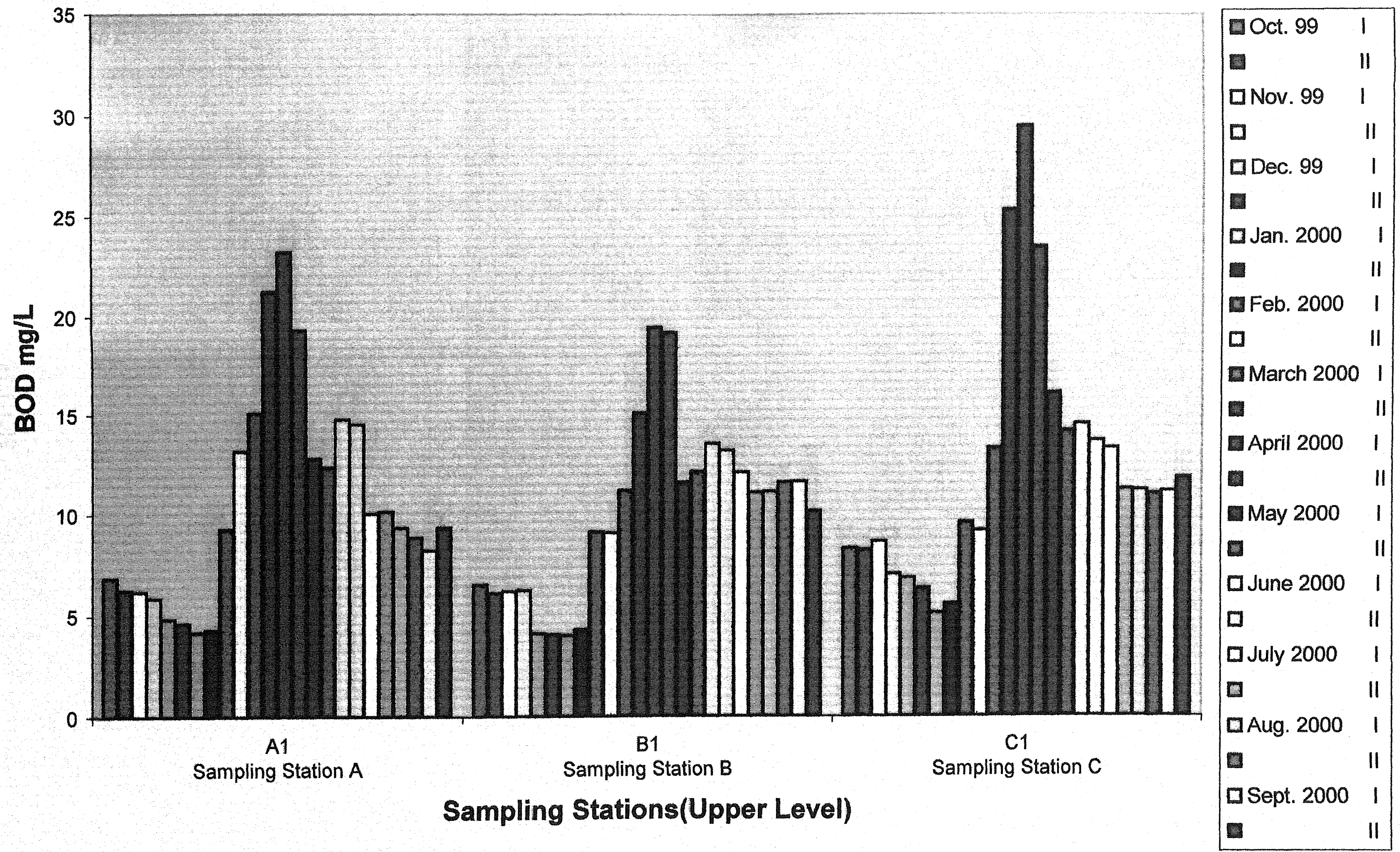


Fig.VIIA2-Monthly Variations In Biochemical Oxygen Demand Mg/L At Different Sampling Stations

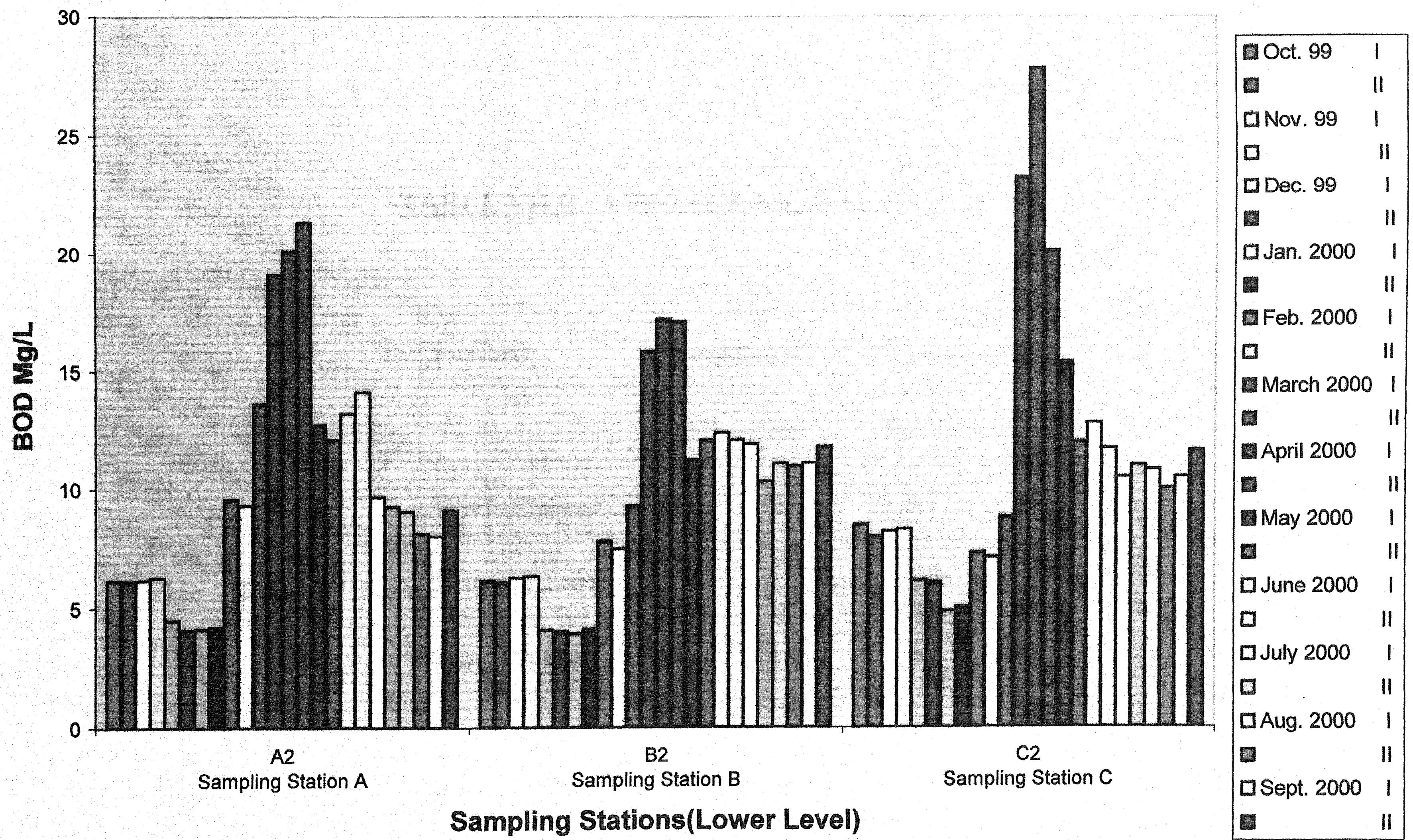


TABLE VII B. AVERAGE VALUES OF BOD IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	5.69	5.62	5.52	5.31	7.16	6.73
Summer Season	16.5	15.19	13.90	12.84	18.20	15.91
Rainy Season	9.67	9.18	10.94	10.69	11.46	10.58

Fig.VIIB-Average Values Of BOD In Different Seasons

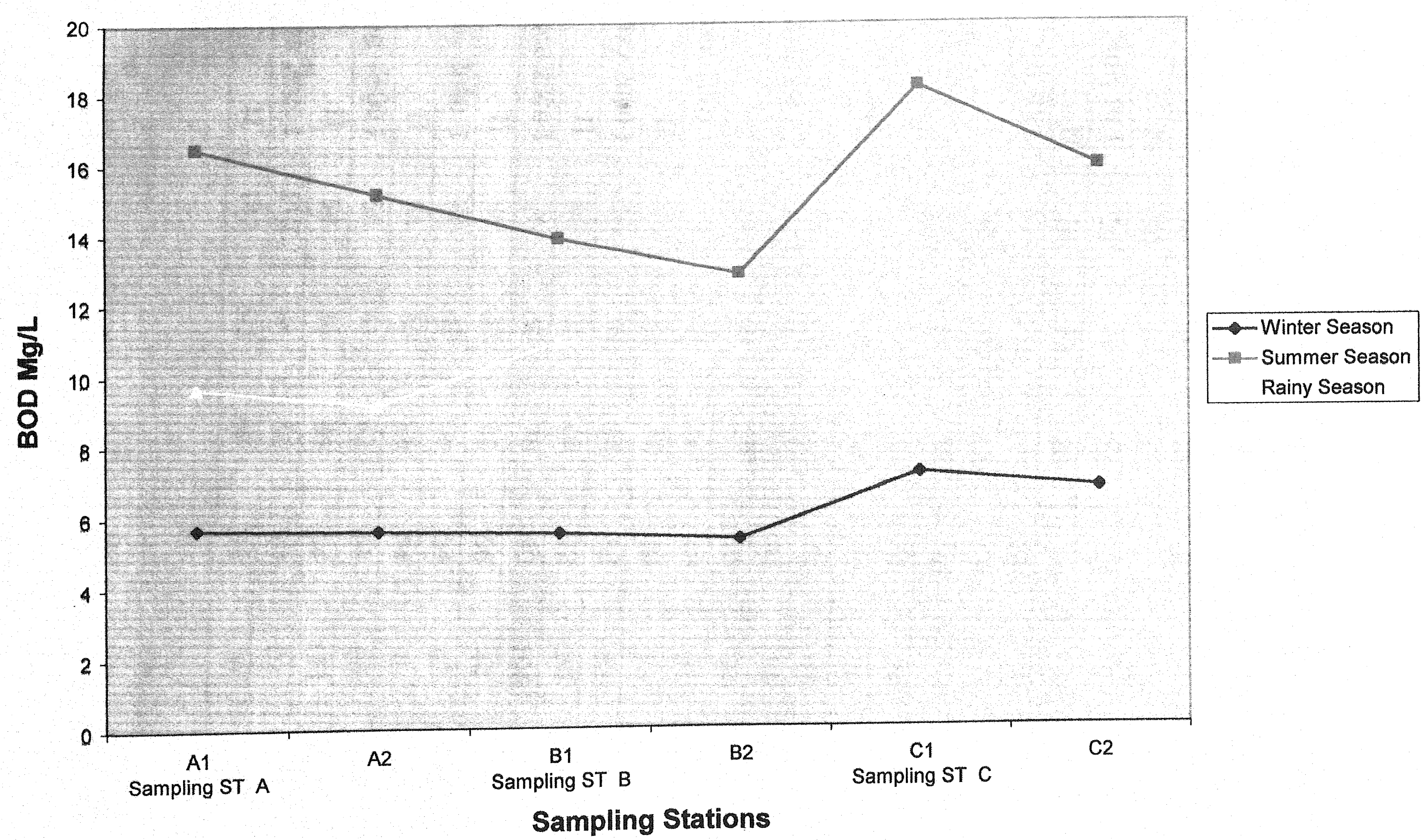


TABLE VIII A MONTHLY VARIATION IN FREE CARBONDIOXIDE mg/L AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST. B		Sampling ST. C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	20	50	20	30	30	36
II	60	74	62	7 6	64	78
Nov. 99 I	36	46	36	42	38	52
II	20	30	20	30	30	40
Dec. 99 I	108	156	114	136	96	110
II	98	120	126	130	74	92
Jan.2000 I	20	30	30	40	20	30
II	40	50	30	50	30	52
Feb.2000 I	20	42	30	56	20	64
II	36	50	40	46	42	78
Mar. 2000 I	44	56	44	48	52	68
II	25	30	20	25	30	37
Apr. 2000 I	50	60	50	40	32	70
II	50	52	58	24	38	68
May 2000 I	50	40	66	52	82	70
II	64	36	68	72	94	80
June 2000 I	76	30	70	90	106	82
II	40	32	62	56	44	70
July 2000 I	48	42	56	54	42	40
II	56	50	58	54	40	34
Aug. 2000 I	56	44	62	56	90	64
II	54	36	68	64	138	114
Sept. 2000 I	110	98	76	70	82	60
II	142	242	98	94	70	110

Fig.VIIIA1-Monthly Variations In Free Carbondioxide mg/L At Different Sampling Stations

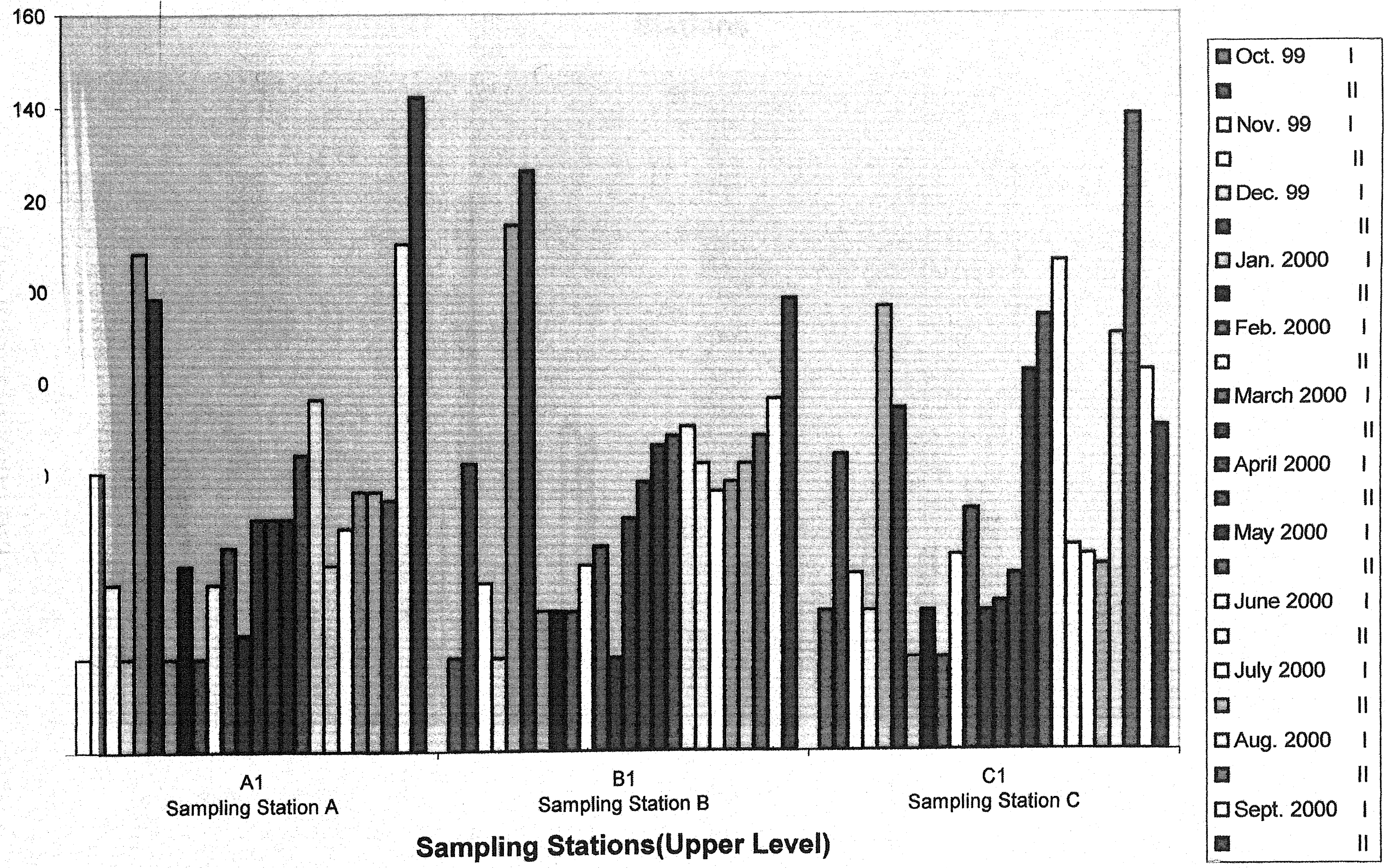


Fig.VIIIA2-Monthly Variations In Free Carbondioxide mg/L At Different Sampling Stations

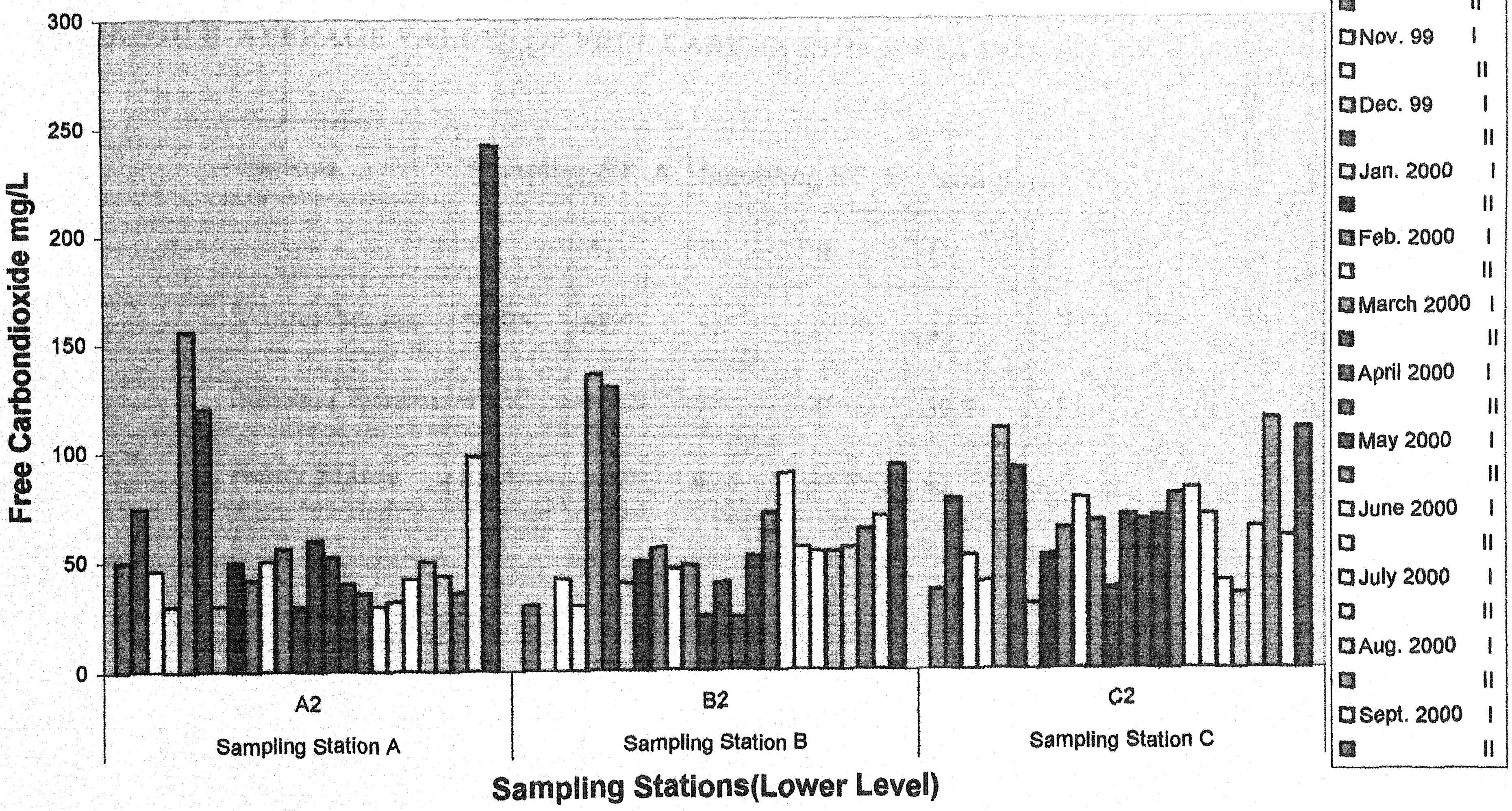


TABLE VIII B. AVERAGE VALUES OF FREE CARBON DIOXIDE IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	50.25	68.5	56	70	46.5	64.75
Summer Season	49.37	44.25	52	49.62	59.5	69.12
Rainy Season	65.75	74.25	62.5	59.75	67	66

Fig.VIIIB-Average Values Of Free Carbondioxide In Different Seasons

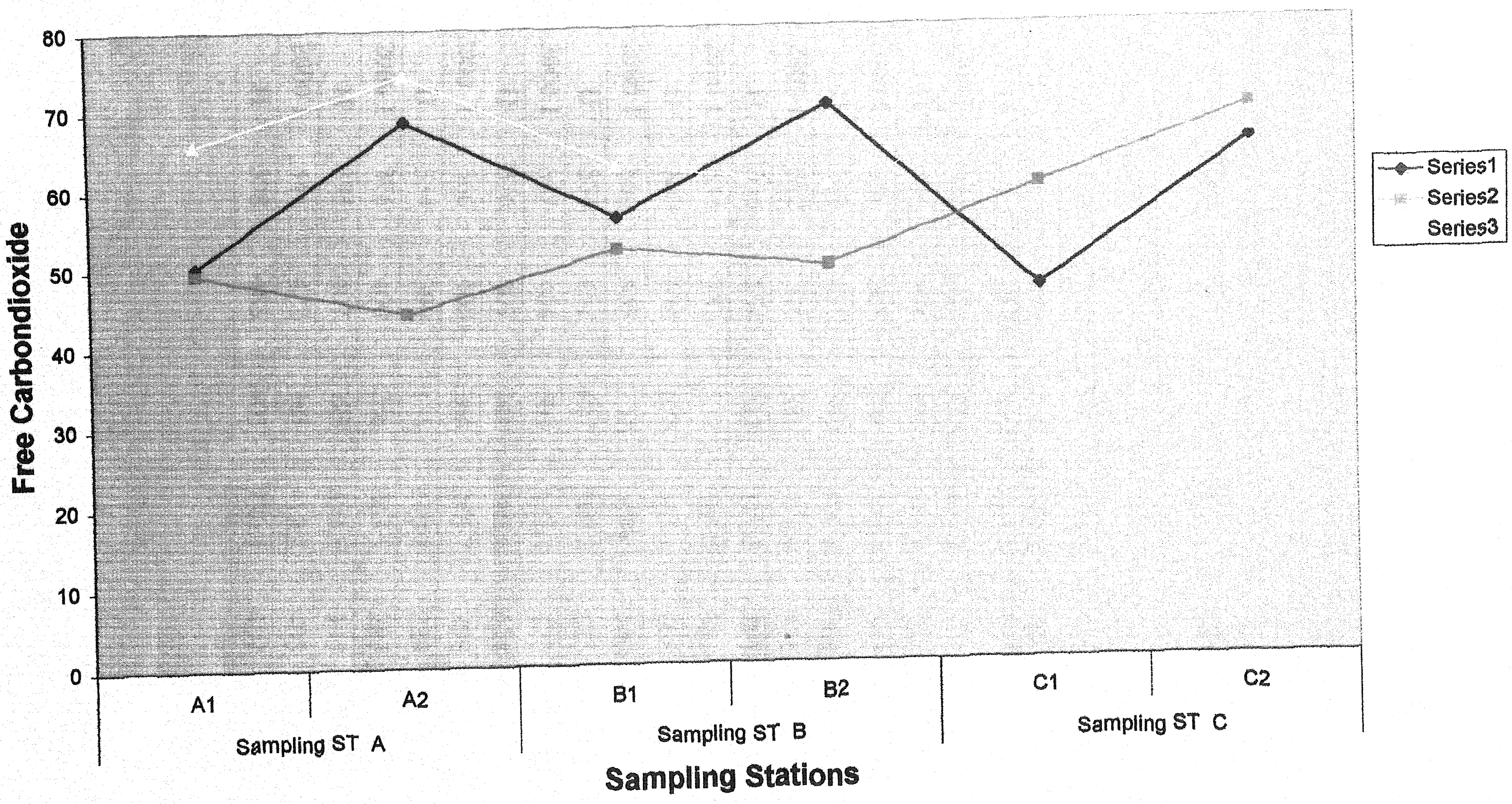
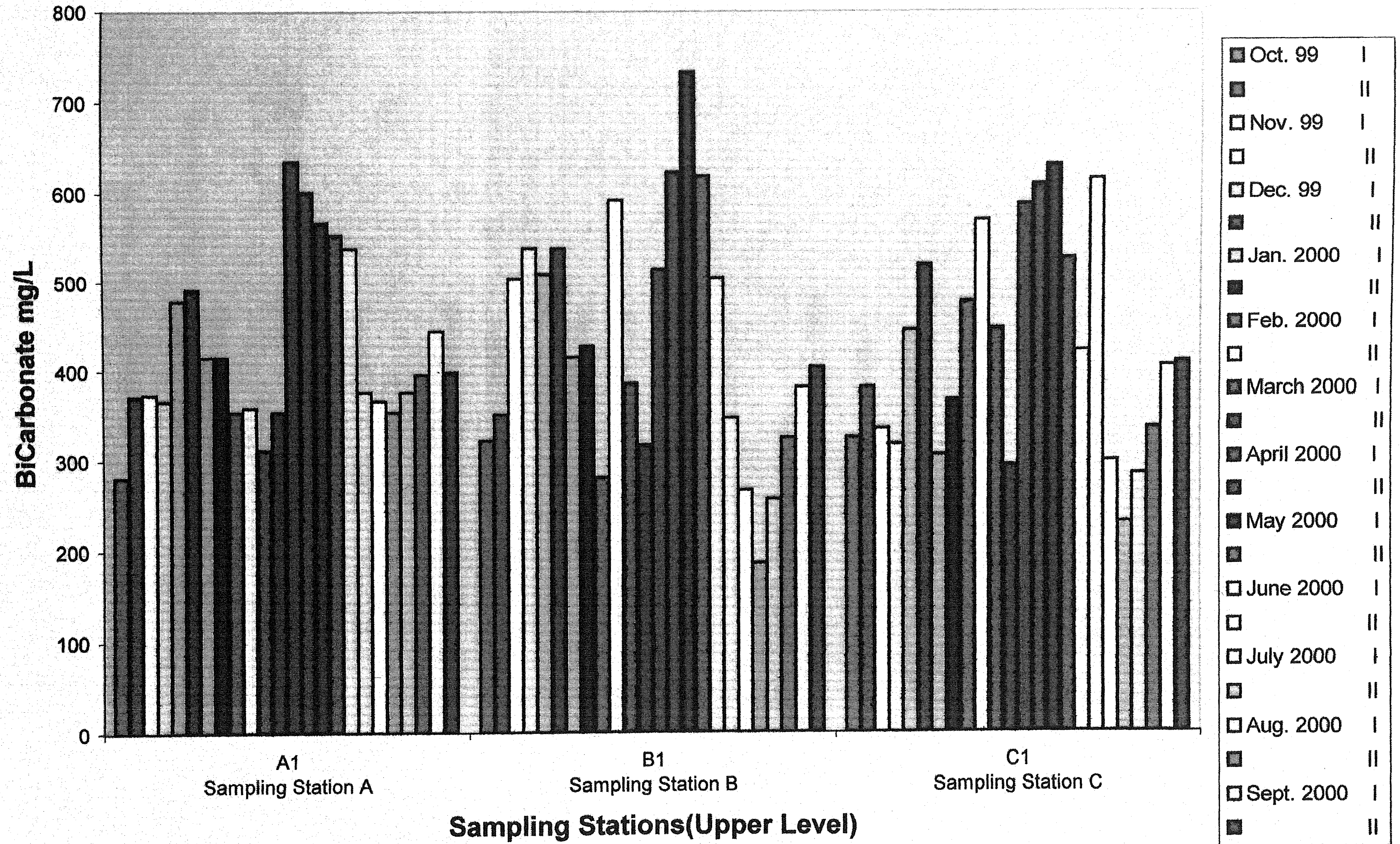


TABLE IX A. MONTHLY VARIATION IN BICARBONATE CONTENT mg/L AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	281	259	322	268.4	325	298
II	371	449	351	461.2	381	442
Nov. 99 I	373	420	503	690.5	334	422
II	366	390	537	573.4	317	366
Dec. 99 I	478	593	508	553.9	444	578
II	490	693	537	507.5	517	498
Jan.2000 I	415	427	415	439.2	305	371
II	415	476	427	475.8	366	488
Feb.2000 I	354	305	281	378.2	476	427
II	359	439	590	636.8	568	476
Mar. 2000 I	312	371	386	470.9	445	256
II	354	354	317	317.2	293	268
Apr. 2000 I	634	732	512	585.6	586	622
II	600	634	622	483.1	608	542
May 2000 I	566	439	732	610	630	451
II	551	451	617	500.2	525	493
June 2000 I	537	464	503	512.4	420	534
II	376	407	346	380.6	614	390
July 2000 I	366	400	266	275.7	298	312
II	354	390	185	170.8	229	234
Aug. 2000 I	376	400	256	263.5	283	290
II	395	407	325	353.8	334	346
Sept. 2000 I	444	422	381	412.4	403	425
II	398	483	403	490.4	407	493

Fig.IXA1-Monthly Variations In Bicarbonate Content mg/L At Different Sampling Stations



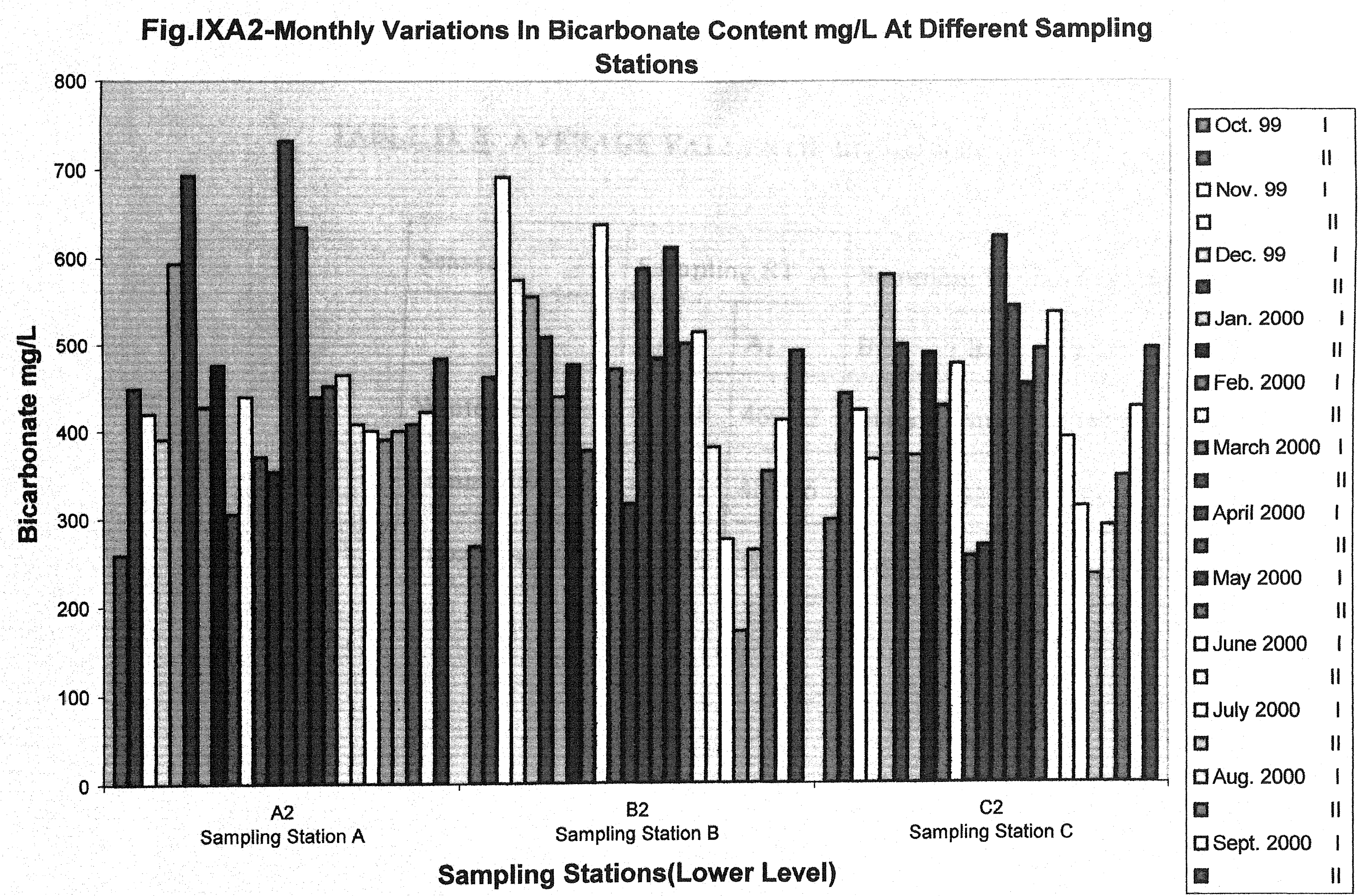


Fig.IXA2-Monthly Variations In Bicarbonate Content mg/L At Different Sampling Stations
Bicarbonate mg/L
800
700
600
500
400
300
200
100
0
A2
Sampling Station A
B2
Sampling Station B
C2
Sampling Station C
Sampling Stations(Lower Level)
Oct. 99 I
II
Nov. 99 I
II
Dec. 99 I
II
Jan. 2000 I
II
Feb. 2000 I
II
March 2000 I
II
April 2000 I
II
May 2000 I
II
June 2000 I
II
July 2000 I
II
Aug. 2000 I
II
Sept. 2000 I
II

TABLE IX B. AVERAGE VALUES OF BICARBONATE IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	407.48	469.12	444.62	509.96	392.53	448.92
Summer Season	489.21	485.56	534.97	514.53	509.1	455.36
Rainy Season	373.58	396.2	310.48	326.96	361.57	348.62

Fig.IXB-Average Values Of Bicarbonate Content In Different Seasons

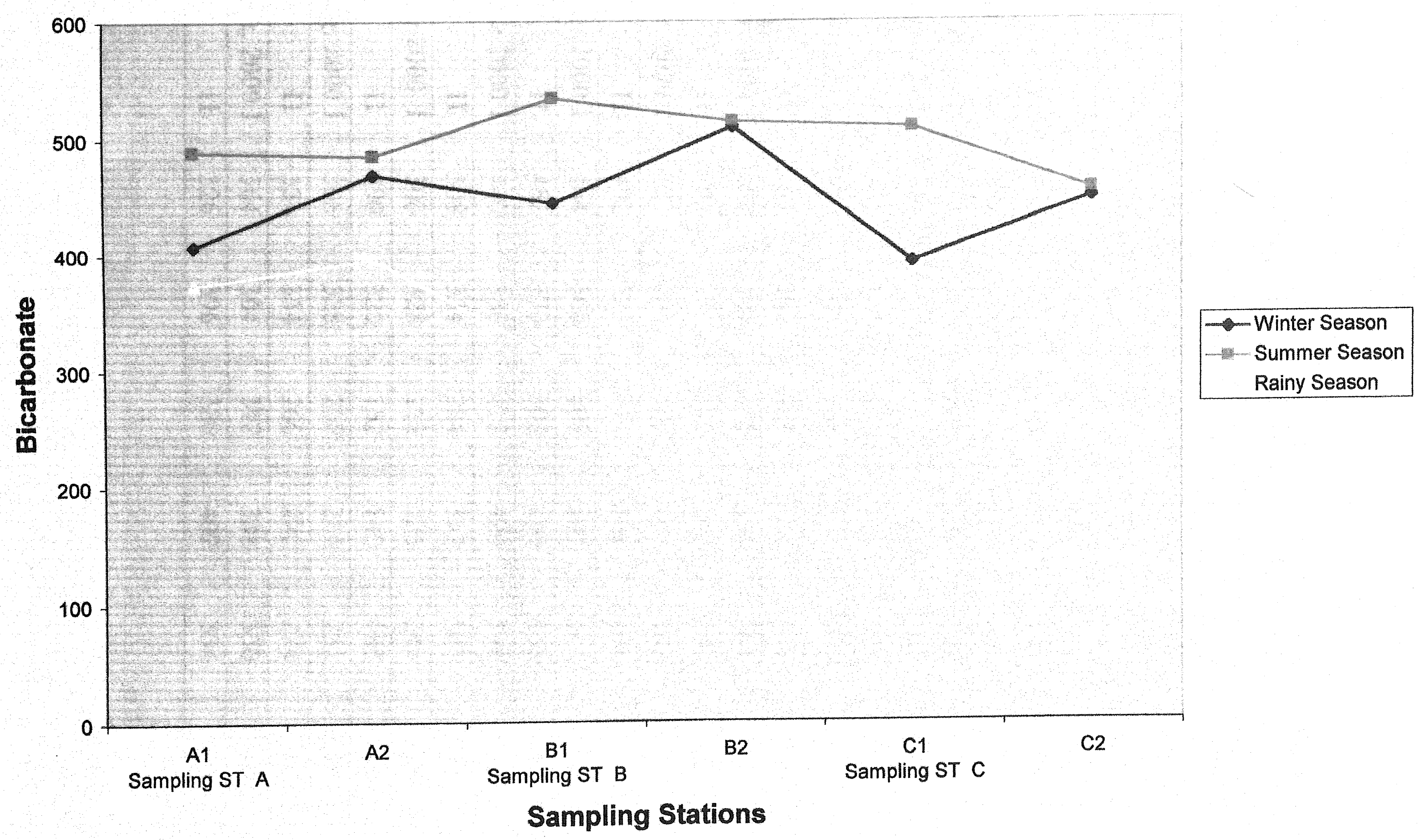


TABLE X A. **MONTHLY VARIATION IN TOTAL ALKALINITY mg/L AT DIFFERENT SAMPLING STATIONS**

Months	Sampling ST. A		Sampling ST. B		Sampling ST. C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	230	212	264	220	266	244
II	304	368	288	378	312	362
Nov. 99 I	306	344	412	446	274	346
II	300	320	440	470	260	300
Dec. 99 I	390	486	416	454	364	474
II	402	568	440	416	424	408
Jan.2000 I	340	350	340	360	250	304
II	340	390	350	390	300	400
Feb.2000 I	290	250	230	310	390	350
II	294	360	484	522	466	390
Mar. 2000 I	256	304	316	386	364	210
II	290	290	260	260	240	220
Apr. 2000 I	520	600	420	480	480	510
II	492	520	510	396	498	444
May 2000 I	464	360	600	500	516	370
II	452	370	506	410	430	404
June 2000 I	440	380	412	420	344	438
II	308	334	284	312	503	320
July 2000 I	300	328	218	226	244	256
II	290	320	152	140	188	192
Aug. 2000 I	308	328	210	216	232	238
II	324	334	266	290	274	284
Sept. 2000 I	364	364	312	338	330	348
II	326	396	330	402	334	404

Fig.XA1-Monthly Variations In Total Alkalinity Mg/L At Different Sampling Stations

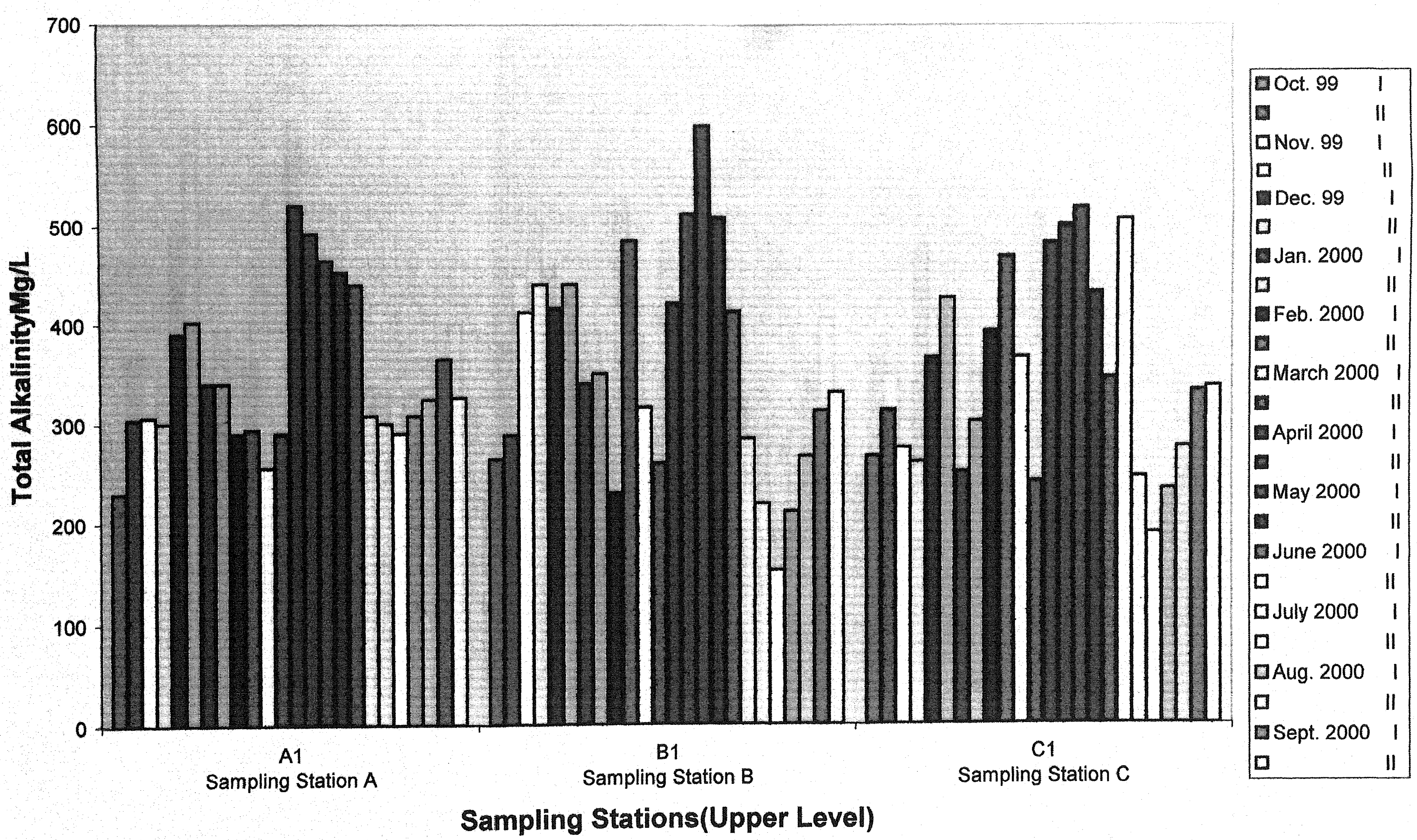


Fig.XA2-Monthly Variations In Total Alkalinity mg/L At Different Sampling Stations

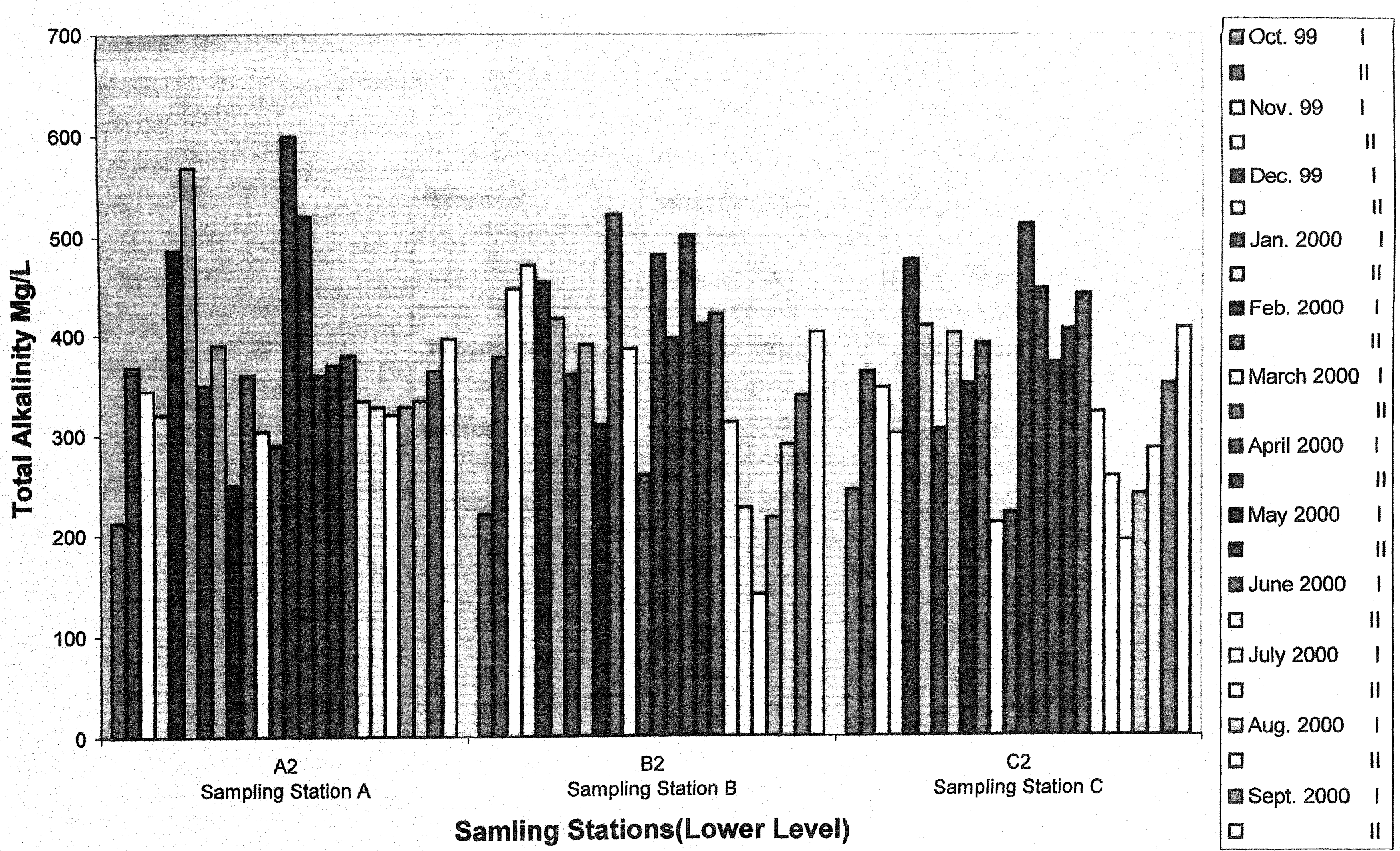


TABLE X B. AVERAGE VALUES OF TOTAL ALKALINITY DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	334	384.5	364.5	403	321.75	368
Summer Season	401	398	438.5	421.75	417.25	373.25
Rainy Season	306.25	327	254.5	268	296.37	285.75

Fig.XB-Average Values Of Total Alkalinity In Different Seasons

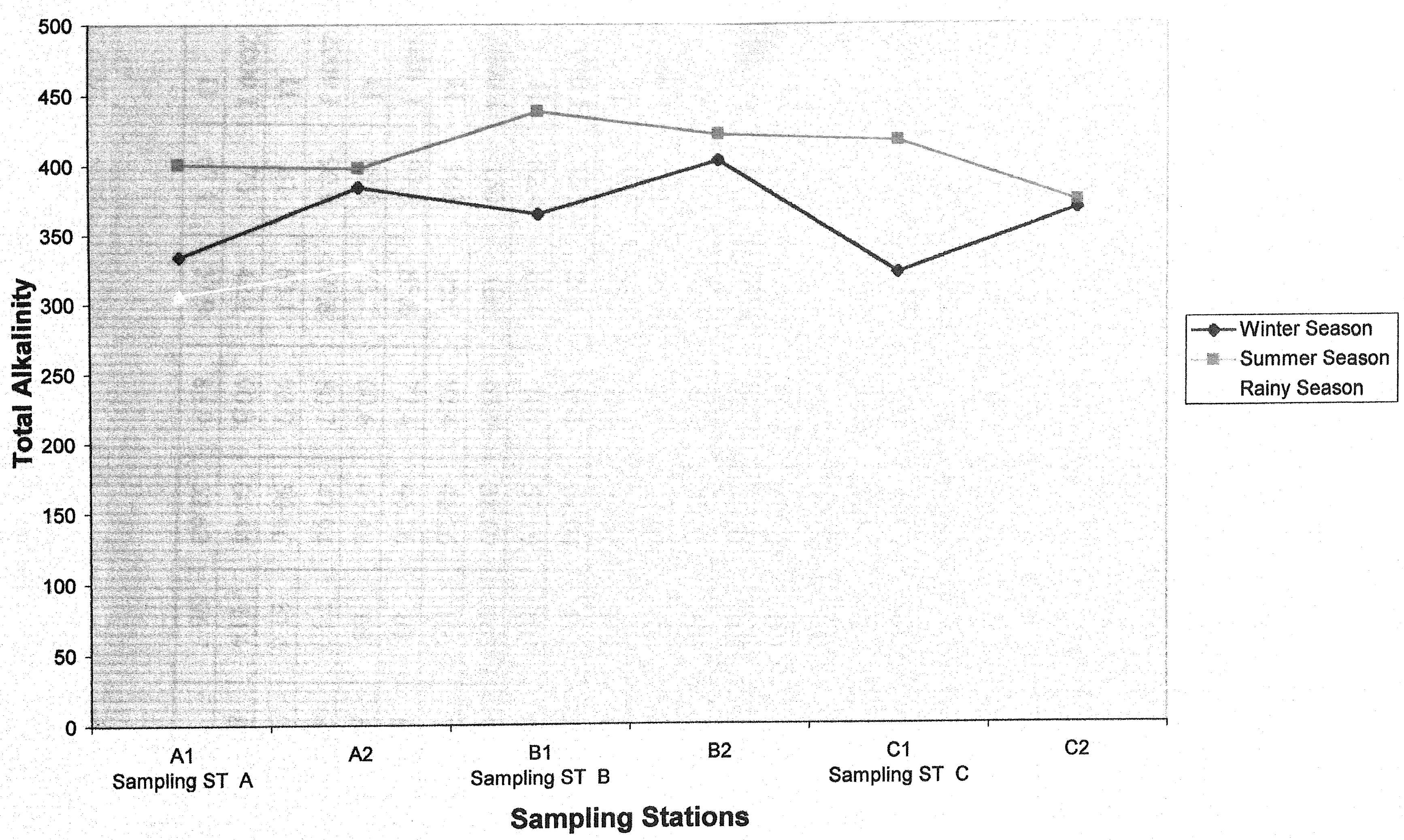


TABLE XI A. MONTHLY VARIATION IN CALCIUM CONTENT mg/L AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	107	147	96.7	86.63	111	90
II	98.4	136	78.2	68.13	83.3	66.4
Nov. 99 I	90	69.8	109	111.9	100	111
II	99.2	52.1	102	57.19	74.8	44.6
Dec. 99 I	85.8	119	91.7	135.4	112	155
II	85.8	130	95.9	132.9	159	153
Jan.2000 I	84.1	58.9	109	147.2	105	145
II	118	96.8	84.2	134.7	92.6	114
Feb.2000 I	79.9	67.3	96.7	92.52	103	108
II	83.3	53	98.4	85.78	101	100
Mar. 2000 I	81.6	45.4	91.7	55.51	102	79.1
II	79.9	37.9	84.1	25.23	103	58
Apr. 2000 I	101	29.4	42.1	21.03	120	41.2
II	95	25.2	85.8	44.58	117	65.6
May 2000 I	35.3	26.1	153	67.04	111	84.1
II	82.4	60.6	109	57.19	107	90.8
June 2000 I	130	100	63.9	38.69	103	96.7
II	108	95.9	93.4	46.26	101	75.7
July 2000 I	97.8	85.8	77.4	46.26	85	66.4
II	89.8	75.7	60.6	45.42	68	57.2
Aug. 2000 I	90.9	69.8	80.7	47.94	75.7	47.1
II	81	63.1	92.9	50.46	81.6	37.9
Sept. 2000 I	73	42.1	90.5	66.44	114	85.8
II	67.1	37.9	86.9	32.62	96.7	27

Fig.XIA1-Monthly Variations In Calcium Content Mg/L At Different Sampling Stations

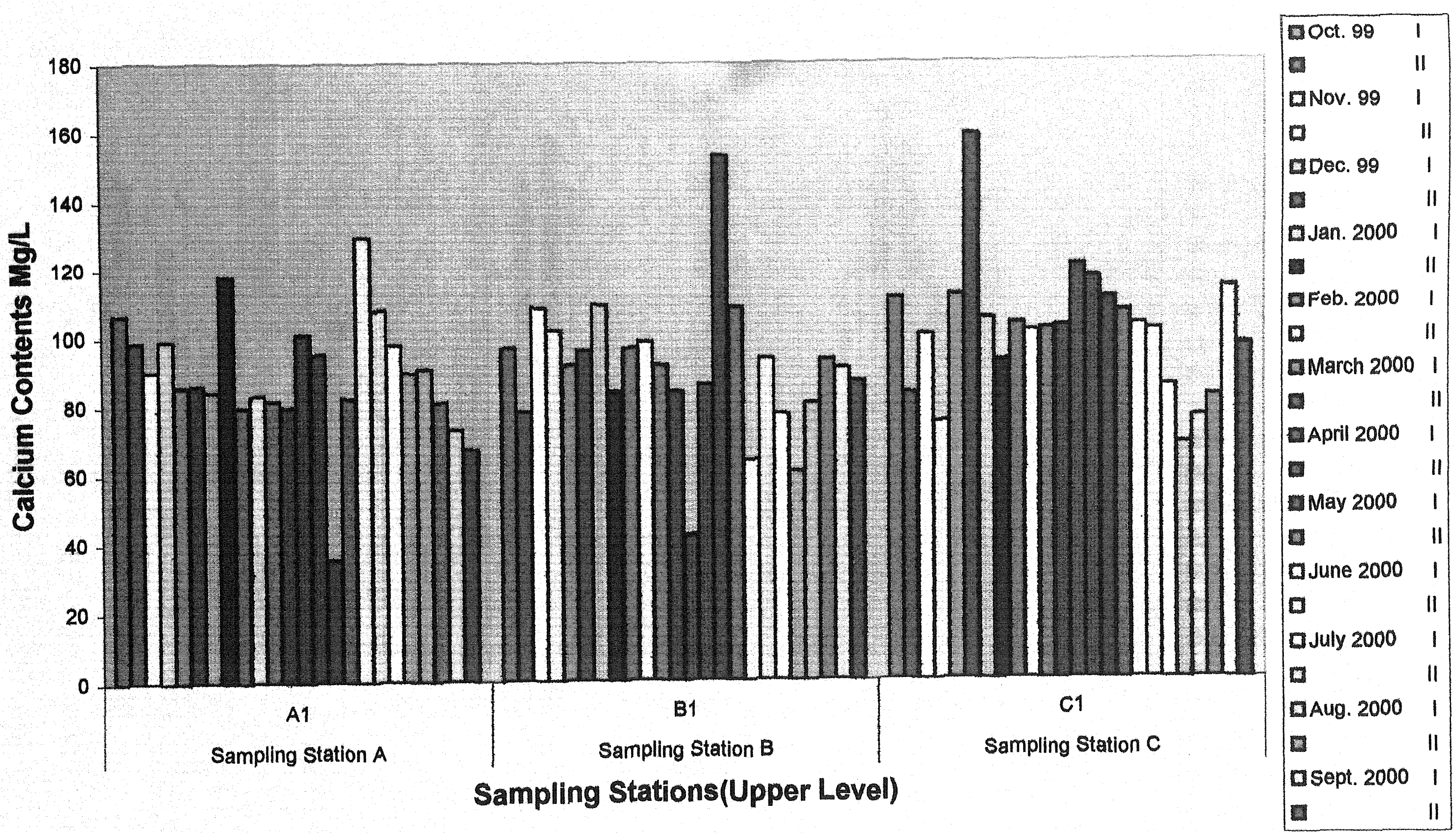


Fig.XIA2-Monthly Variations In Calcium Content Mg/L At Different Sampling Stations

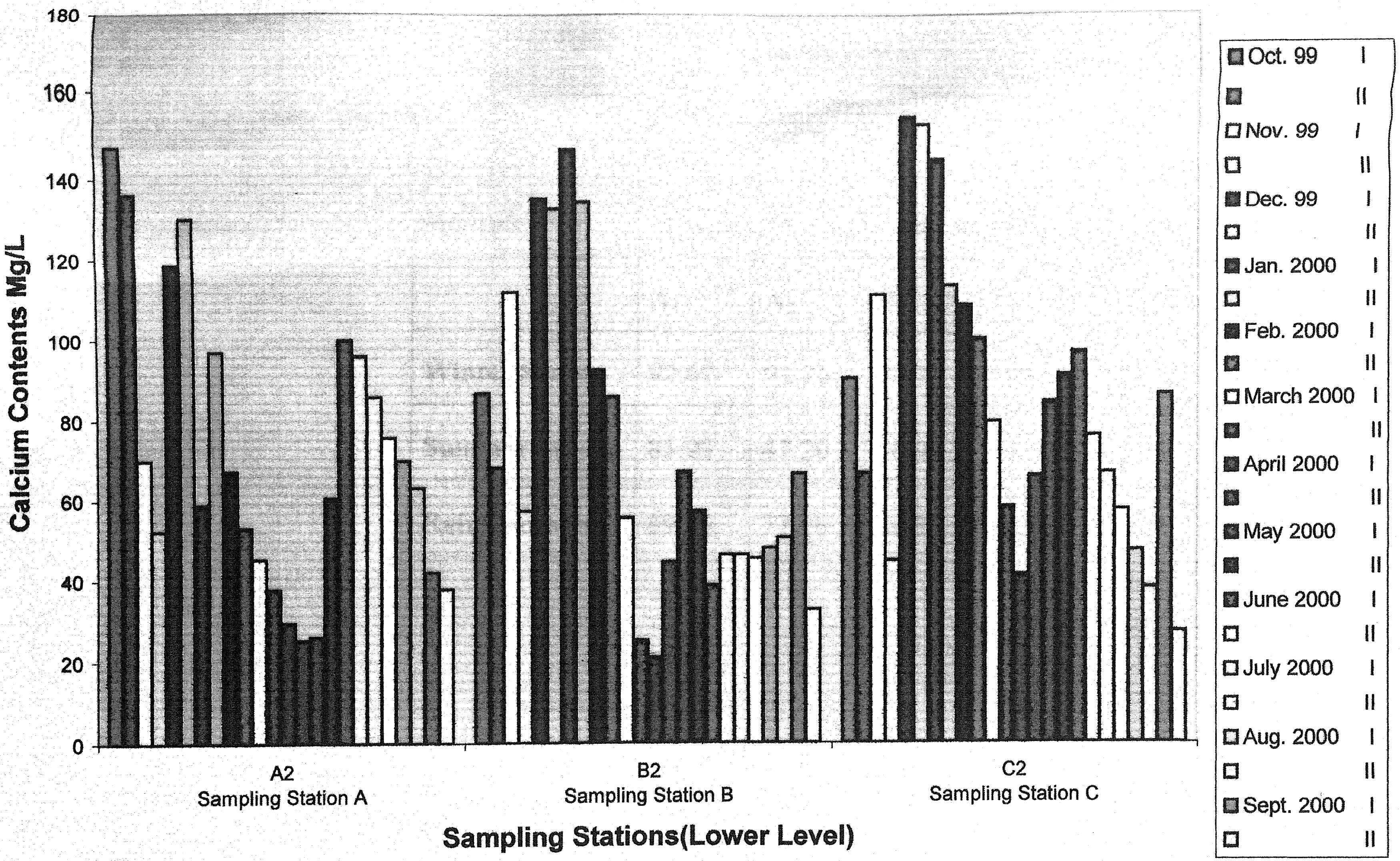


TABLE XI B. AVERAGE VALUES OF CALCIUM CONTENT IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	92.62	91.26	95.77	109.98	103.76	112.06
Summer Season	85.99	47.20	90.93	49.50	107.86	76.95
Rainy Season	89.28	77.16	84.89	52.75	91.67	60.88

Fig.XIB-Average Value Of Calcium Content In Different Seasons

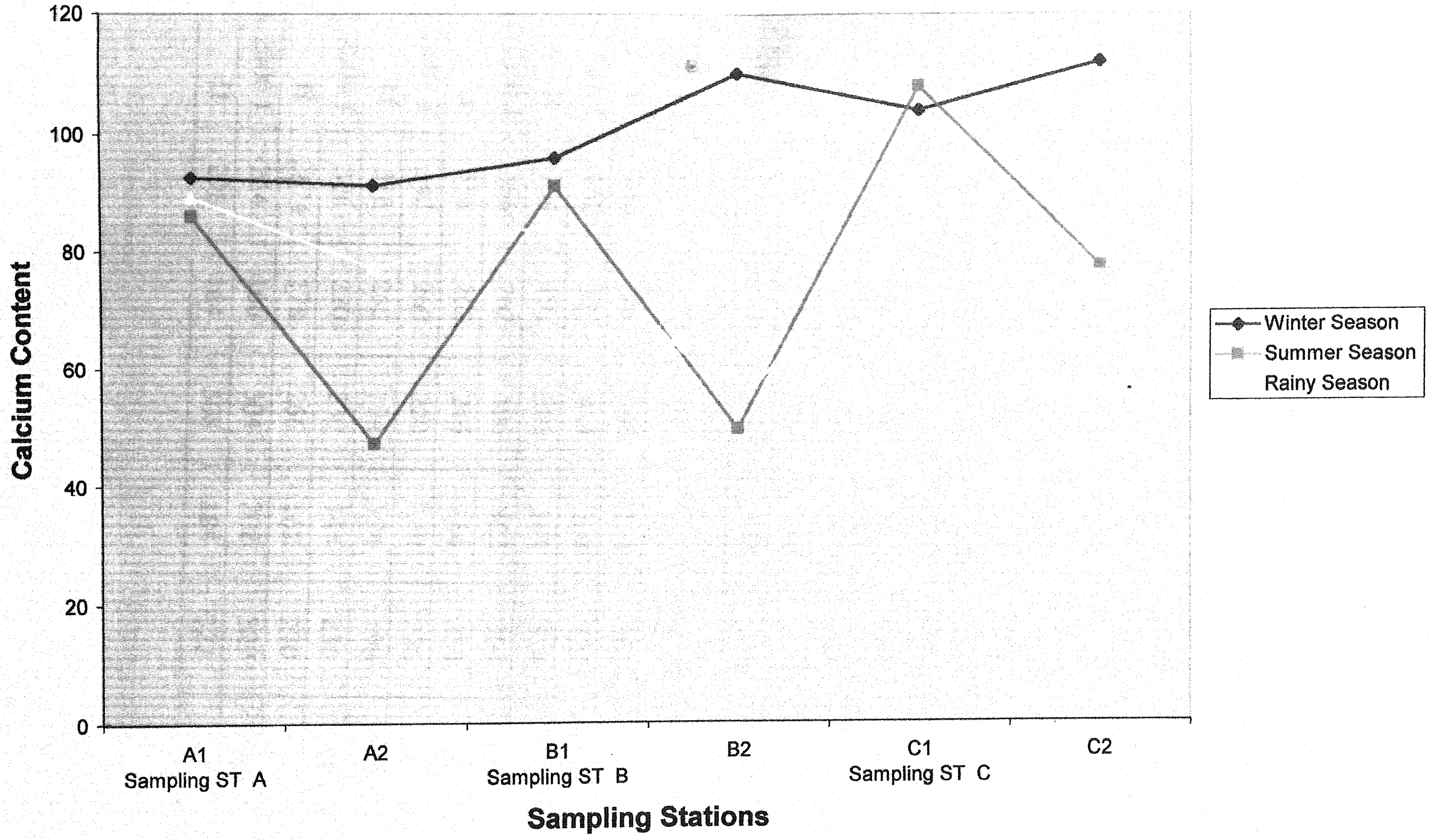


TABLE XII A. MONTHLY VARIATION IN TOTAL HARDNESS AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST. B		Sampling ST. C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	300	384	266	256	288	242
II	264	370.	242	230	232	212
Nov. 99 I	286	236	276	328	278	334
II	326	238	314	244	248	204
Dec. 99 I	234	346	304	402	348	434
II	275	354	284	346	432	438
Jan.2000 I	274	226	208	394	302	392
II	346	276	266	384	286	356
Feb.2000 I	244	234	286	304	324	310
II	232	182	264	246	306	264
Mar. 2000 I	236	166	244	122	298	216
II	244	200	268	118	294	186
Apr. 2000 I	298	164	224	102	314	146
II	262	96	246	154	306	178
May 2000 I	152	122	414	204	322	266
II	254	192	306	184	314	258
June 2000 I	356	262	196	162	304	292
II	358	262	246	154	254	196
July 2000 I	342	260	220	140	226	190
II	326	262	194	124	198	184
Aug. 2000 I	306	220	230	144	236	166
II	2874	178	266	162	270	146
Sept. 2000 I	264	166	304	202	329	290
II	298	164	308	184	322	264

Fig.XII A1-Monthly Variations In Total Hardness Mg/L At Different Sampling Stations

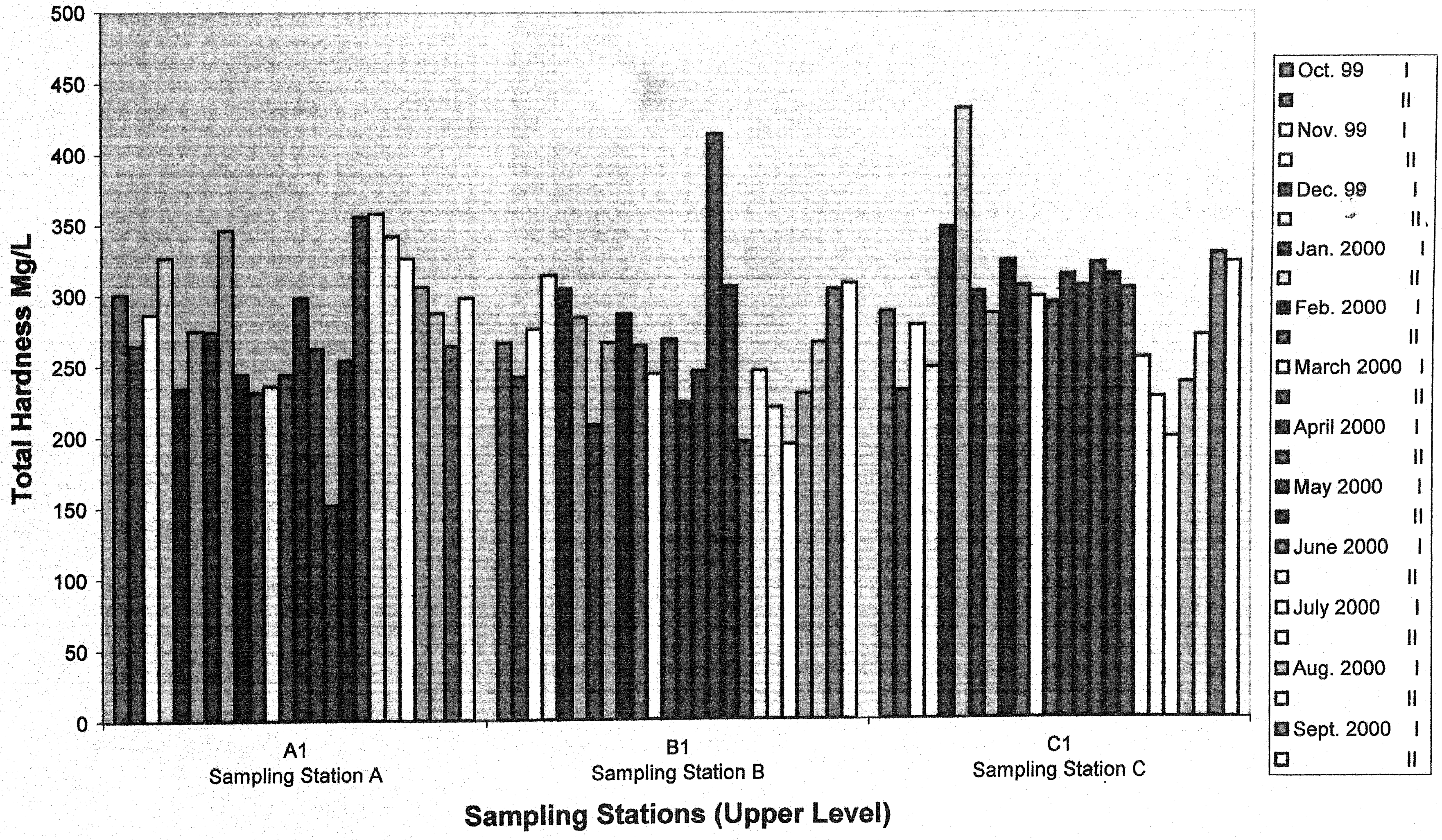


Fig.XIIA2-Monthly Variations In Total Hardness Mg/L At Different Sampling Stations

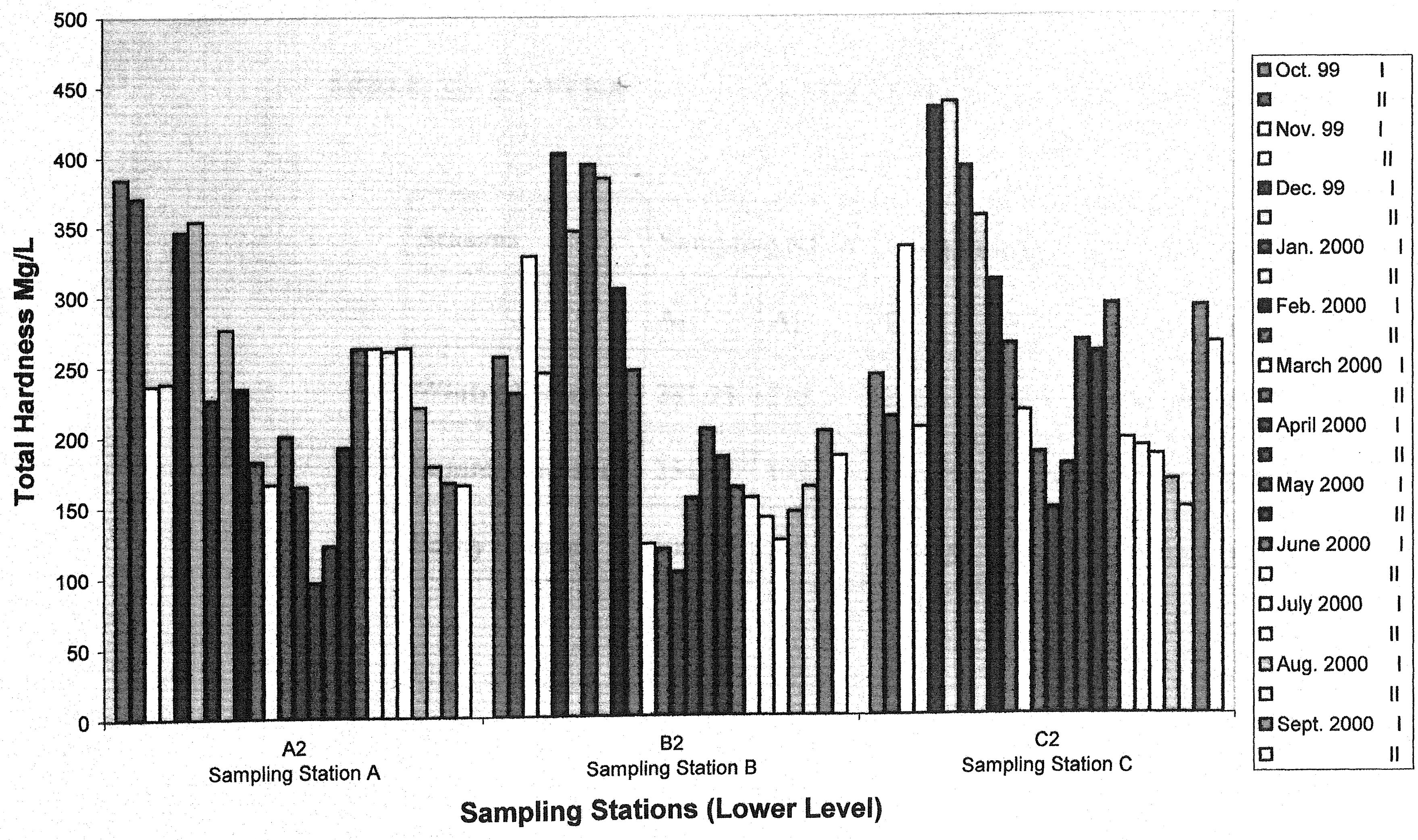


TABLE XII B. AVERAGE VALUES TOTAL HARDNESS IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	281.25	215	272.5	329	306.25	335
Summer Season	254.25	173	270.25	161.15	307.25	225.75
Rainy Season	309.75	237	254.25	170.75	265.32	209.75

Fig.XIIB-Average Values Of Total Hardness In Different Sesons

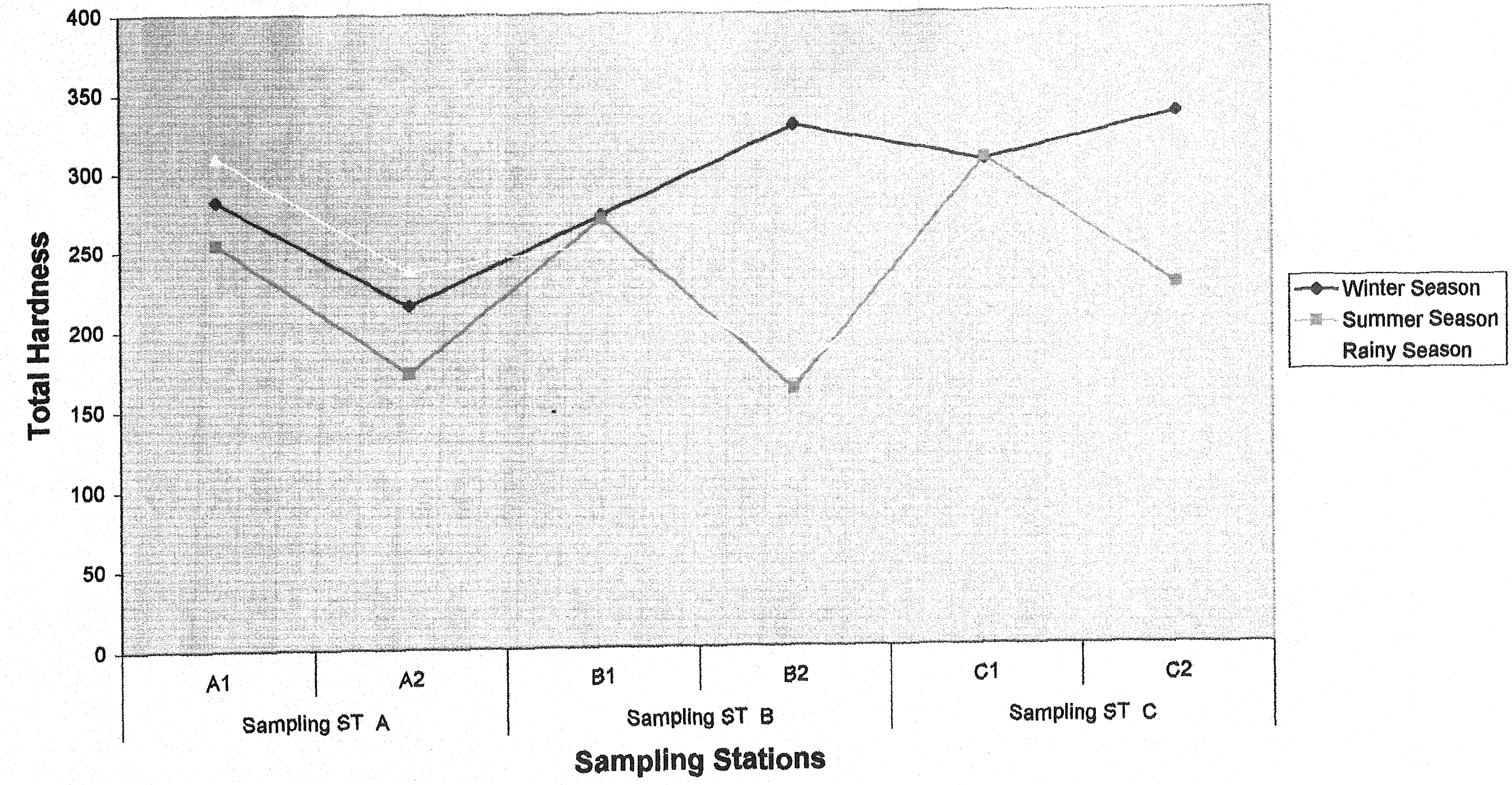


TABLE XIII A. MONTHLY VARIATION IN MAGNESIUM CONTENT AT DIFFERENT SAMPLING STATIONS

Months	Sampling ST. A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Oct. 99 I	22.8	4.05	5.98	9.69	2.56	4.22
II	4.47	7.27	11.4	14.62	5.88	11.3
Nov. 99 I	47.8	40.6	40.9	62.25	43.4	54.4
II	19.1	26.3	14.8	24.69	14.9	22.6
Dec. 99 I	36.2	55.5	51.8	65.05	57.6	68.1
II	15.1	6.95	10.9	3.46	8.56	13.6
Jan.2000 I	15.6	19.3	14.9	6.47	9.64	7.52
II	12.7	8.42	13.7	11.71	13.4	17.7
Feb.2000 I	10.9	16.1	10.9	17.81	16	9.54
II	5.88	12.2	4.47	7.76	13.8	3.44
Mar. 2000 I	36.2	29.4	37.2	16.22	47.9	33.4
II	10.9	25.7	14.2	13.42	9.22	10
Apr. 2000 I	11.2	22.1	29	12.08	3.34	10.5
II	6.03	8.05	7.76	10.42	3.44	3.46
May 2000 I	15.6	13.9	7.76	4.17	10.9	13.7
II	11.8	8.42	8.56	10.05	11.5	7.61
June 2000 I	7.95	6.03	8.88	15.96	11.7	12.3
II	3.32	5.51	3.15	9.39	0.49	1.7
July 2000 I	5.56	11.2	6.54	5.98	3.39	5.88
II	7.8	17.8	10.4	4.12	6.3	10.1
Aug. 2000 I	6.51	11.2	6.93	5.93	11	11.8
II	4.73	5	3.42	8.78	16.2	12.6
Sept. 2000 I	9.59	14.9	5	8.81	11	18.5
II	12.2	9.32	5.1	8.92	5.3	10.1

Fig.XIIIA1-Monthly Variations In Magnesium Content Mg/L At Different Sampling Stations

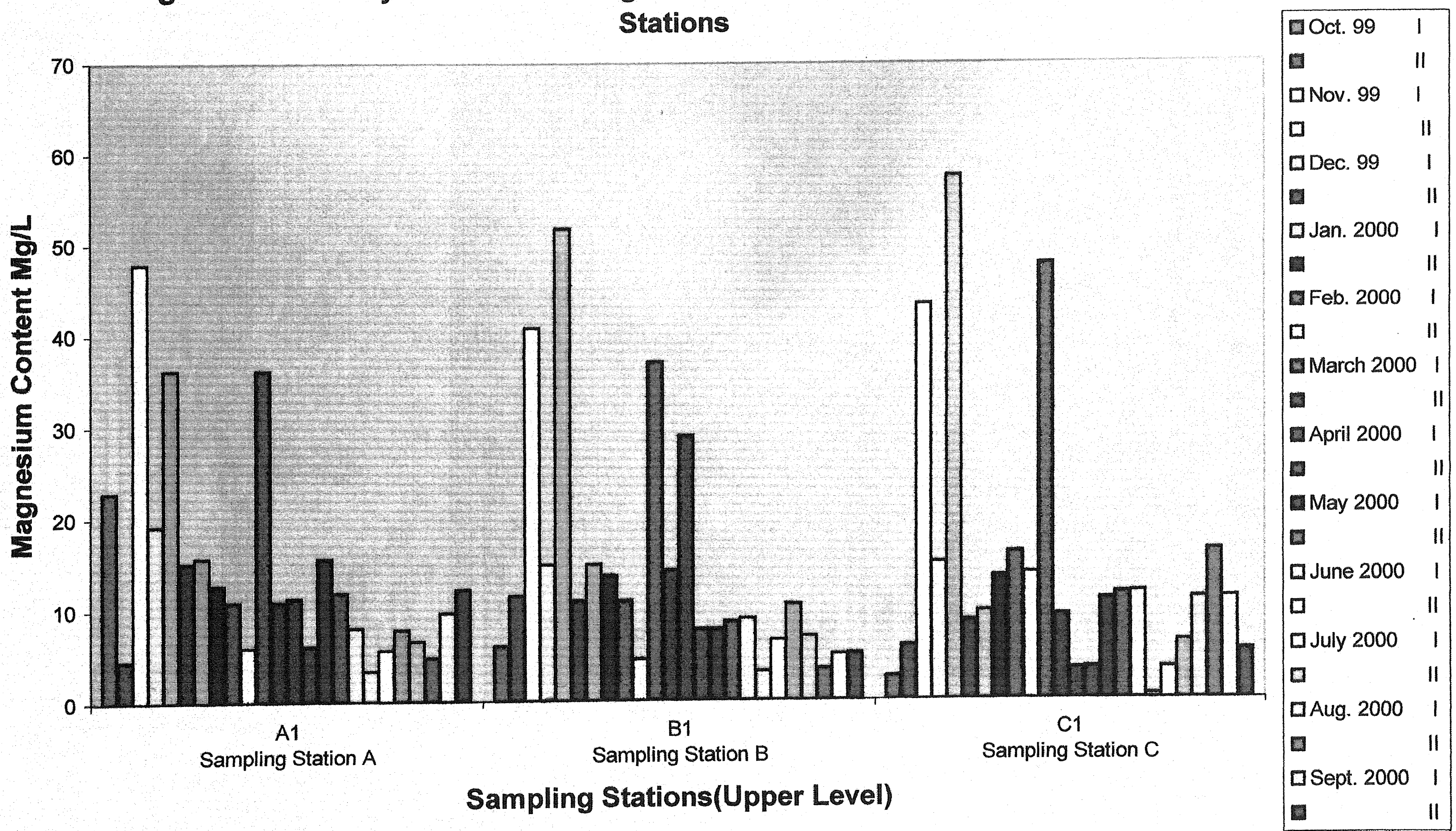


Fig.XIIA2-Monthly Variations In Magnesium Content Mg/L At Different Sampling Stations

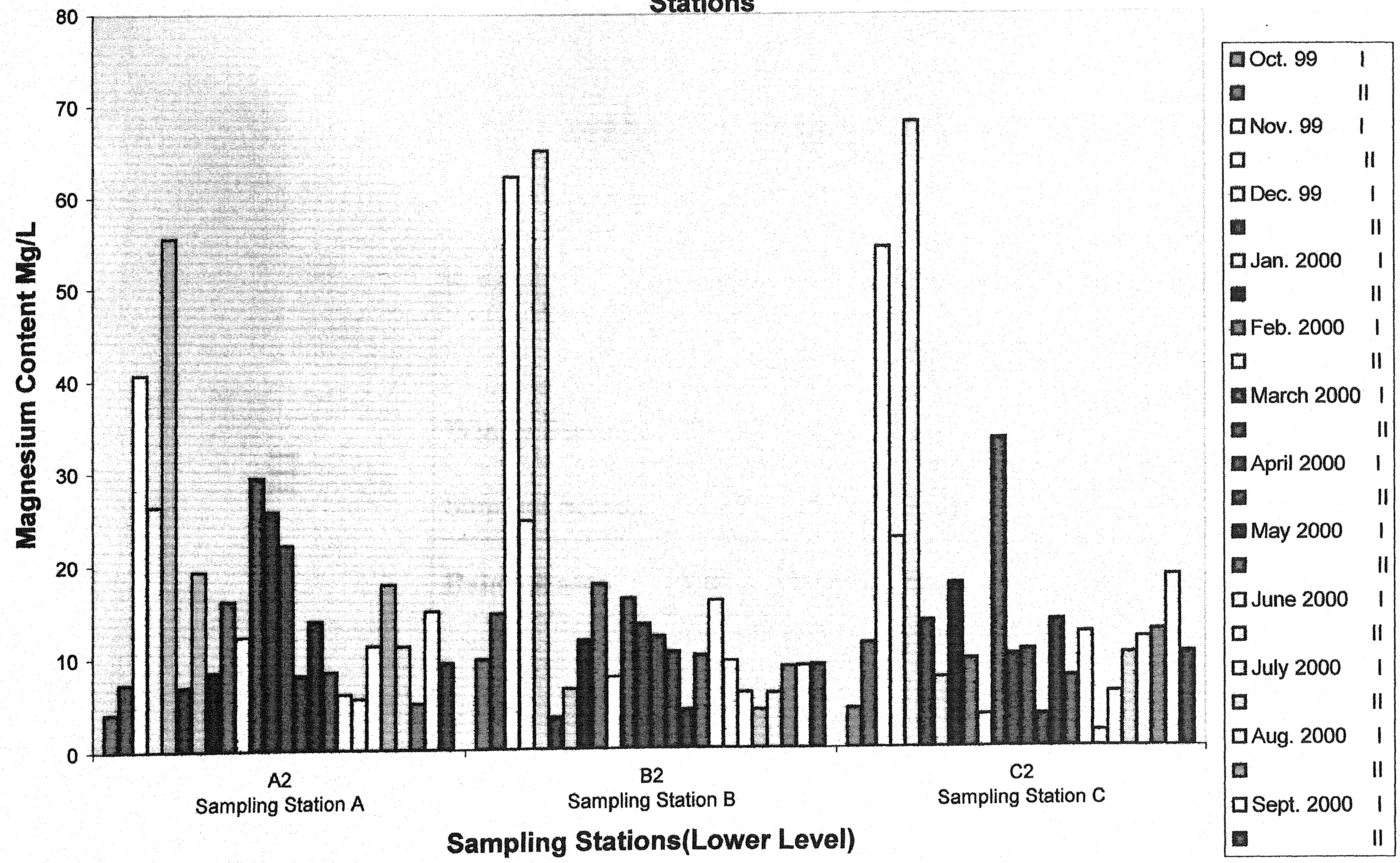
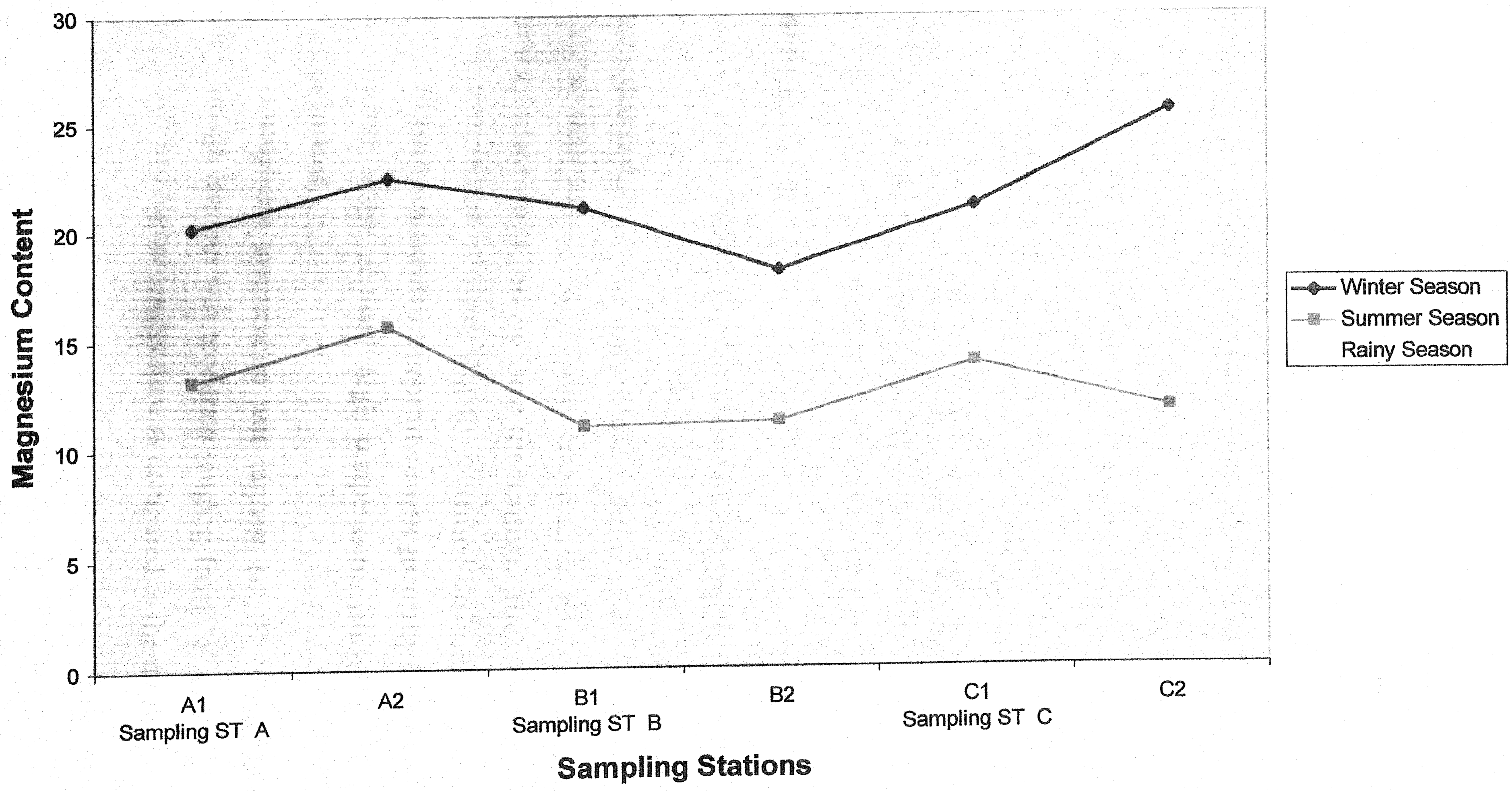


TABLE XIII B. AVERAGE VALUES OF MAGNESIUM IN DIFFERENT SEASONS

Seasons	Sampling ST A		Sampling ST B		Sampling ST C	
	A_1	A_2	B_1	B_2	C_1	C_2
Winter Season	20.22	22.54	21.14	18.25	21.18	25.59
Summer Season	13.18	15.72	11.09	11.26	13.97	11.80
Rainy Season	9.05	9.86	5.82	7.7	7.02	9.35

Fig.XIIIB-Average Value Of Magnesium Content In Different Seasons



SECTION –4 CHAPTER'B'

DIURNAL VARIATION IN PHYSICO-CHEMICAL PARAMETERS - OBSERVATIONS

In the present study diurnal variation in physico-chemical parameters were studied. The study was carried out on 3rd March for 24 hours at 4 hours interval. Samples were collected from predetermined three sampling stations A, B and C from each sampling station seperate samples were collected from the surface and from a depth varying from 4 to 5 fts. The methods of analysis were the same as followed during analysis at fortnight intervals and on the same parameters. The datas obtained have been given in Table XIV. The results obtained are being mentioned below parameterwise.

1. TEMPERATURE

During this day atmospheric temperature varied from 14 ^{0}C to 21 ^{0}C. From the datas obtained in the table it will be evident that during the early hours in the morning that is 4.30 am, the temperature of the atmosphere was similar or slightly higher than that of water. Lower temperature of water was found at depth but the surface water had the same temperature. After four hours i.e. at 8.30 am the temperature of water slightly increased both at surface and at depth. At 12.30 noon atmospheric temperature was generally higher than that of water. Surface water showed high temperature while at depth the temperature decreased.

At 4.30 pm atmospheric temperature was highest i.e. 21 ^{0}C while water temperature, though less but was moderate ranging from 18^0 to 20 ^{0}C. Here also surface water had higher temperature as compared to the depth.

At 8.30 pm atmospheric temperature was 19 ^{0}C. The water temperature, at surface was similar or slightly lower while the temperature at depth showed lower, equal or slightly higher temperatures.

During midnight atmospheric temperature was 14 ^{0}C but the water temperature raised between 15^0 to 18 ^{0}C that is both surface and lower level waters recorded slightly high temperatures as compared to that of atmosphere.

In general water temperature ranged between 15 ^{0}C to 22 ^{0}C and excepting the sample collected at 8.30 am the rest of the sample showed variation in the temperature of water at surface and at depth.

No fixed trend can be drawn for the entire area studied as the trend varied from station to station.

2. CONDUCTIVITY

From the datas recorded it can be observed that conductivity remained almost the same at all places and at different depths. It ranged between 0.7 m Mhos to 0.8 mMhos. In general both surface water and water at depth gave the same value except at sampling station A where water at depth recorded higher value at 4.30 am; 4.30 pm, 8.30 pm and 12.30 midnight. Similar position was found at sampling station B at 12.30 noon and at sampling station C at 4.30 am.

In general it can be said that water at depth may have similar or higher conductivity as compared to that of surface water.

3. pH

The pH of the reservoir did not show much variation during the diurnal studies, however it was noted to be slightly towards the alkaline side. The

values ranged from 7.3 to 8.2 pH. Slight variations sometimes were observed during the day times but during evening and night not much variations were observed. At few sampling stations variations were observed in upper and lower level of water but no particular trend could be observed as sometimes the pH of upper level was higher, while on the other occasion it was equal or lower.

During midnight however the lower level water showed a lower pH value as compared to that of the upper level.

4. CHLORIDE

The values of chloride content varied from one sampling station to the other. The entire study area did not show a fixed pattern therefore results obtained are being discussed station wise.

AT SAMPLING STATION 'A'

Chloride content of the surface water and that of the lower region increased from 4.30 am to 12.30 noon. This rise was less in the surface water as compared to that of the lower level .Chloride content of surface water at 4.30 am was 83.47 mg/L. At 8.30 am it was 94.97 mg/L and at 12.30 noon this value had increased to 116.96 mg/L.

At the lower level at 4.30 am the value was 73.98 mg/L; at 8.30 am it was 109.97 mg/L while at 12.30 noon it was 156.45 mg/L. Thus an increasing trend could be concluded. From 12.30 noon Chloride content gradually decrease to 8.30 pm in both surface and lower level water samples.

At 4.30 pm the surface water had 115.96 mg/L at 8.30 pm the value was 91.47 mg/L while at the under surface at 4.30 pm it was 124.97 mg/L, at 8.30 pm its value was 109.97 mg/L.

At midnight the values at both the surface increased.

These values show that there was a gradual increase in Chloride content of 4.30 am to 12.30 noon, then there was a gradual decrease till 8.30 pm, then again it increased at night.

While comparing the Chloride content of upper and lower surfaces it was observed that the value of the upper surface was lower as compared to the lower surface from 8.30 am to 8.30 pm, then the reverse position was found at midnight till 4.30 am.

AT SAMPLING STATION 'B'

At this sampling station the value of chloride content fluctuated at each sampling period. However the general trend was similar in both upper and lower surfaces.

At 4.30 am the surface and lower level waters gave the value 113.87 mg/L and 108.47 mg/L respectively. At 8.30 am these values increased to 142.96 mg/L and 158.45 mg/L respectively. At 12.30 noon again value decreased to 56.48 mg/L and 102.97 mg/L respectively. At 4.30 pm this value again increased to 107.47 mg/L and 156.45 mg/L respectively.

Then at 8.30 pm these values decreased to 101.47 and 105.47 mg/L respectively, then again at 12.30 night values increased to 116.46 and 121.46 mg/L respectively. Thus a zigzag type of trend could be noted.

When the chloride content of two levels are compared it can be observed that the value of lower level water had a higher chloride content as compared to that of the surface water except at 4.30 am where a reverse position was found.

AT SAMPLING STATION 'C'

At this site the surface water and the lower level water showed different trends. The surface water had an increasing value of chloride content from 4.30 am to 4.30 pm while the lower surface water had its Chloride content in a decreasing trend during the same period. At the surface its value increased from 95.47 mg/L to 127.46 mg/L while the undersurface water's Chloride content decreased from 132.46 mg/L to 72.48 mg/L at 4.30 pm.

At 8.30 pm value of Chloride content decreased in the surface water to 94.47 mg/L whereas the under surface Chloride content increased to 103.97 mg/L. At midnight both these values increased and the values recorded were 123.96 mg/L of surface water and 152.95 mg/L of the undersurface water. Therefore the surface water showed increasing values from 4.30 am to 4.30 pm while undersurface water gave a decreasing value, thereafter during night both the values showed increasing trend.

When the chloride content of both the water levels is compared it can be said that from 8.30 am to 4.30 pm the values of upper surface were higher as compared to the lower surface. From 8.30 pm to 4.30 am the values of Chloride content of the lower surface were higher as compared to the values of surface.

5. DISSOLVED OXYGEN

The values of Dissolved Oxygen showed fluctuations in surface water and submerged water. These values also vary from one sampling station to the other. Dissolved oxygen (DO) was found to be ranging from 1.81 mg/L to 9.48 mg/L. The values changed from one site to the other and thus stationwise results are being given below -

AT SAMPLING STATION 'A'

At this sampling station Dissolved Oxygen always remained higher at the surface water as compared to the lower water level except at 8.30 pm when the dissolved oxygen was found to be more at the lower level as compared to the upper level.

In the surface water Dissolved Oxygen was found to be 3.43 mg/L at 4.30 am and at 8.30 am. At 12.30 noon it raised to 7.86 mg/L then at 4.30 pm it reduced to 5.24 mg/L and then at 8.30 pm and midnight the values were found to be reduced to 2.82 mg/L, this was the minimum value of DO at the surface water while its maximum value was found at 12.30 noon when the value of 7.86 mg/L was recorded.

At the lower level little variations were recorded. At 4.30 am it was 3.23 mg/L, then at 8.30 am the value reduced to 2.22; at 12.30 noon it increased to 3.43 mg/L. At 4.30 pm it increased to 4.23 mg/L and at 8.30 pm it further increased to 6.86 mg/L while at midnight the value was again reduced to a minimum level of 1.89 mg/L. It can be said that at the lower surface the value increased gradually from 2.22 mg/l to 6.85 mg/L upto 8.30 pm, then it declined in the midnight and increased at 4.30 am. Thus the lower surface

showed more changes during the daily periodicity as compared to the surface water.

AT SAMPLING STATION 'B'

At this sampling site the value of Dissolved Oxygen varied in surface water and at the lower level water. At three stages of sampling i.e. at 4.30 am, 12.30 noon and 4.30 pm the value of dissolved oxygen in the surface water was more as compared to the lower surface. However at rest of three sampling stages i.e. at 8.30 pm and 12.30 midnight DO was found to be more at the lower surface as compared to the upper surface.

At the upper surface at 4.30 am Dissolved Oxygen was 8.27 mg/L, then at 8.30 am it reduced to 2.02 mg/L and at 12.30 noon the value increased to its maximum level of 9.48 mg/L then it gradually reduced upto 12.30 midnight i.e.at 4.30 pm the value was 7.66 mg/L, at 8.30 pm its value was 6.05 and at 12.30 midnight value of 2.82 mg/L was recorded. Almost the same pattern was recorded at the lower level where the values decreased from 4.30 am to 12.30 noon then gradually increased till 8.30 pm and then again reduced at 12.30 midnight.

At 4.30 am the DO at the lower level was 5.24 mg/L. At 8.30 am it was recorded to be 4.44 and then at 12.30 noon it further reduced to 2.22 mg/L, thereafter at 4.30 pm the value increased to 4.03 mg/L and at 8.30 pm it further increased to 6.25 mg/L, while at midnight its value reduced to 3.83 mg/L.

AT SAMPLING STATION 'C'

At this sampling station the values of Dissolved Oxygen were found to be more or equal in the surface water except at 8.30 pm where more value was

recorded in the lower level water as compared to the upper surface. At two sampling stages i.e. at 8.30 am and 12.30 midnight the values were same at both the surfaces where values of 2.22 and 4.23 mg/L were recorded respectively. At 4.30 am and 12.30 noon the upper surface had a higher value as compared to the lower surface.

At 4.30 am upper surface had Dissolved Oxygen equal to 6.05 mg/L while at lower level a value of 5.85 was recorded. At 12.30 noon 4.44 mg/L was recorded at the upper surface and 1.61 was recorded in the lower surface.

The value of Dissolved Oxygen of the surface water was found to be 6.05 mg/L at 4.30 am. At 8.30 am it reduced to 2.22 mg/L then at 12.30 noon it increased to 4.44 mg/L then at 4.30 pm it again increased to 5.65 mg/L and then the value further increased at 8.30 pm to 5.85 mg/L, thus from 8.30 am to 8.30 pm the values gradually increased and then at midnight it reduced to 4.23 mg/L.

At the lower surface the value gradually decreased from 4.30 am to 12.30 noon, at 4.30 am it was 5.85 mg/L, at 8.30 am it reduced to 2.22 mg/L and at 12.30 noon it further reduced to 1.61 mg/L. thereafter the value increased to 4.03 at 4.30 pm and at 8.30 pm the value further increased to 6.23 mg/L while at midnight it reduced to 4.23 mg/L. The minimum value was obtained at 12.30 noon and the maximum at 8.30 pm.

From the overall studies it can be said that there was no fixed pattern of rise and fall in the amount of Dissolved Oxygen. It reduced and increased at different times at individual sites and the values of surface and lower level varied and changed independently of the other sites.

6. BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD of water showed almost the similar trend at two sites of sampling i.e. sampling site A and C while at the other sampling site – B, slight difference was found. At sampling sites A and C BOD values were found to be more in the surface water as compared to the lower waters. At sampling station B the similar was found at four sampling stages while reverse trend was found at rest of the sampling stages. The stationwise analysis of BOD values is as follows :-

AT SAMPLING STATION 'A'

As already stated at this sampling station BOD value of the surface water was found to be always higher than the submerged water. The value of BOD in surface water gradually increased from 4.30 am to 4.30 pm and then it gradually decreased to midnight. At 4.30 am surface water gave a BOD value of 8.43 mg/L; at 8.30 am it increased to 10.55 mg/L; at 8.30 am it increased to 10.55 mg/L then at 12.30 noon it increased to 13.12 mg/L and at 4.30 pm the value further enhanced to its maximum of 13.45 mg/L.

At 8.30 pm it decreased to 12.11 and at 12.30 midnight it further decreased to 9.56 mg/L. Similar trend was found in BOD value of the lower level water. At 4.30 am its value was minimum i.e. 7 .02 mg/L then it increased at 8.30 am to 9.36 mg/L, at 12.30 noon it further increased to 11.66 and at 4.30 pm it increased to a maximum level of 11.86 mg/L. At 8.30 pm it reduced to 10.12 mg/L and at 12.30 midnight its value reduced to 7.22.

At this sampling station it can be said that the minimum values were found at 4.30 am and a maximum at 4.30 pm of both surface and submerged waters. Overall the values gradually increased upto 4.30 pm, then gradually decreased till 4.30 am.

AT SAMPLING STATION 'B'

At this sampling station also the minimum values were obtained at 4.30 am but the trend was quite different from that of sampling station A.

The surface water showed a minimum value of 7.88 at 4.30 am then it increased to 9.72 mg/L at 8.30 am. This value further increased to 11.72 mg/L at 12.30 noon then at 4.30 pm the value increased to its maximum of 11.84 mg/L. After this the value decreased at 8.30 pm to 10.81 mg/L and then at 12.30 the value further decreased to 8.12 mg/L. Thus the upper surface followed almost the same trend as found at sampling station A.

The undersurface water showed a slight different position where litle fluctuations were noted after 12.30 noon. At 4.30 am BOD of the under surface water was recorded to be 8.92 mg/L, this increased to 9.12 mg/L at 8.30 am and at 12.30 noon the value further increased to a maximum of 9.44 then the value decreased at 4.30 pm when a value of 9.12 mg/L was recorded. At 8.30 pm it again increased to 9.40 mg/L and at 12.30 midnight it again reduced to 9.24 mg/L.

AT SAMPLING STATION 'C'

At this sampling station the trend was similar to sampling station A in the sense that more values were recorded in surface water than in the submerged water, otherwise there was a slight different trend.

The surface value showed slight fluctuations during the day time. At 4.30 am its value was 9.88 then at 8.30 am it increased to 11.36 at 12.30 noon it reduced to 10.12 mg/L. Then again at 4.30 pm it increased to maximum of 13.12 mg/l and there onwards it reduced i.e. at 8.30 pm value recorded was 12.10 mg/L and at midnight it was 10.82 mg/L. The minimum value of the surface water was recorded at 4.30 am.

The undersurface water showed a different trend its value was 7.12 at 4.30 am then it increased to 10.42 mg/L at 8.30 am. At 12.30 noon it decreased to 8.88 mg/L, it again increased to 9.48 mg/L at 4.30 pm and there onwards a decline was observed till 4.30 am i.e. at 8.30 pm the value reduced to 8.08 mg/l at 12.30 midnight it further reduced to 7.56.

From the overall datas it can be said that generally BOD was found to be higher at upper level as compared to lower level. The minimum values were found to be at 4.30 am and maximum at 4.30 pm with variations at few sampling sites in submerged waters.

7. FREE CARBONDIOXIDE

The variation in Free Carbondioxide at two surfaces did not show a fixed trend till 12.30 noon. Sometimes it was more in surface water and sometimes in subsurface water that too at different sampling stations, at different sampling stages. From 4.30 pm to 12.30 midnight the free carbondioxide showed a definate trend with context to the two levels, that is it was usually found to be more in lower level water at all sampling stations. From 4.30 pm to 12.30 midnight the value of free CO_2 was usually higher as compared to the early hours of the day.

AT SAMPLING STATION 'A'

At 4.30 am the Free Carbondioxide value was more in lower level water than in the surface water, values being 62 mg/L and 76 mg/L respectively. At 8.30 am the Free Carbondioxide content increased in the surface water from 62 (at 4.30 am) to 72 mg/l and reduction was observed in lower level water to 20 mg/L. At 12.30 noon further reduction in Free Carbondioxide was observed at both the levels of water, value being higher at the surface as

compared to the lower level water, values being 16 mg/L and 14 mg/L respectively.

At 4.30 pm the surface water value remained same and slight rise in the value of Free Carbondioxide in water from lower level was observed (from 14 mg/L to 16 mg/L), the Free Carbondioxide content at both the levels was same.

At 8.30 pm and 12.30 midnight gradual increase in the Free Carbondioxide value was observed and maximum values were observed at 12.30 midnight. At both these sampling stages the Free Carbondioxide was more in lower level water as compared to upper level water. The peak values at 12.30 midnight were 180 mg/L at surface and 364 mg/L at lower level, thereafter the values showed decline till 4.30 am.

AT SAMPLING STATION 'B'

From 4.30 am to 4.30 pm no fixed trend could be observed thereafter from 8.30 pm to 12.30 midnight value of Free Carbondioxide increased. Peak values were observed at 12.30 midnight (186 mg/L and 232 mg/L respectively in surface water and lower level water) and it was usually higher in lower level water at these two sampling stages.

At 4.30 am the Free Carbondioxide in surface water was more than that in lower level water, 78 mg/L and 62 mg/L respectively.

At 8.30 am there was decline in the values of carbondioxide at both the levels, the trend however changed that is it was higher in lower level water at this stage. The values being 16 mg/L at upper level and 20 mg/L in lower level water.

At 12.30 noon there was slight rise in free carbondioxide in surface water and in lower level water further reduction in the free carbondioxide content was observed. The value in surface water was higher as compared to lower level water.

At 4.30 pm the value of Free Carbondioxide was same at both the levels and the value had increased as compared to the previous sampling stage (i.e. 12.30 noon), the value being 26 mg/L.

From 8.30 pm to 12.30 midnight there was rise in the amount of free carbondioxide at both the levels reaching the peak at 12.30 midnight. During these sampling stages the carbondioxide content was low in surface water and higher in lower level water. At 8.30 pm the values of free carbondioxide were 94 mg/L in upper level water and 154 mg/L in lower level water. At 12.30 midnight the values were 186 mg/L and 232 mg/L respectively at the two different levels.

AT SAMPLING STATION 'C'

At this sampling station the trend observed was nearly same as that found in water samples from other sampling stations.

At 4.30 am the free carbondioxide was greater in lower level water (C_2) as compared to upper level water, values being 84 mg/L (in C_2) and 62 mg/L (in C_2) respectively.

At 8.30 am reverse was observed that is Free Carbondioxide was more in surface water than in lower level water. The Carbondioxide amount was however comparatively less.

At 12.30 noon there was slight increase in the amount of Free Carbondioxide in lower level water, from 14 mg/L to 26 mg/L. The Free Carbondioxide content in surface water remained same as that found at 8.30 am.

At 4.30 pm Free Carbondioxide value had reduced, the value in lower level water was more as compared to surface water.

At 8.30 pm and 12.30 midnight the trend was same as that found in water of other two sites, i.e. Free Carbondioxide content was more in lower level water as compared to that in surface water and there was increase in amount of Free Carbondioxide reaching its peak at 12.30 midnight (204 mg/L in surface water and 282 mg/L in lower level water).

8. BICARBONATE CONTENT

Studies on diurnal variations of Bicarbonate content of the pond under study generally showed a higher value in waters at depth as compared to that of the surface. However quantitative differences were found at different sampling sites. The results obtained have been shown in the TABLE XIV and accordingly the results are being given below sitewise.

AT Sampling Station 'A'

The results obtained and shown in the table referred above it will be clear that the minimum value was obtained at 4.30 am and the maximum value at 12.30 midnight in surface water.

The surface water at 4.30 am gave Bicarbonate content 170.44 mg/L which increased at 8.30 am to 175.6 mg/L and again at 12.30 noon the value further increased to 187.88 mg/L. This value slightly decreased at 4.30 pm to 178.32 mg/L and thereafter a gradual increase can be observed.

At 8.30 pm its value was 183.48 mg/L and at 12.30 midnight its value was 236.32 mg/L. This shows that surface water had a gradual increase from 4.30 am to 12.30 noon thereafter it dropped down at 4.30 pm and then gradually increased to midnight which again declined at 4.30 am.

The undersurface water had more fluctuations as compared to the upper surface. However the values were generally higher to those obtained at the surface level. At 4.30 am Bicarbonate content was found to be 187.88 mg/L which dropped to 180.56 mg/L at 8.30 am and this enhanced at 12.30 noon to 192.76 mg/L then again it dropped 190.12 mg/L at 4.30 pm and at 8.30 pm the value was nearly the same i.e. 190 mg/L. This increased to 190.68 at 12.30 midnight. Thus from a graphical sketch it will appear to be in a zigzag position.

AT SAMPLING STATION 'B'

At this sampling site the Bicarbonate content was found to have almost a similar trend i.e. higher values at the lower surface and less value of the surface water.

The surface water had a minimum value at 4.30 am with Bicarbonate content equal to 170.88 mg/L. At 8.30 am it increased to 185.44 mg/L. At 12.30 noon its value was 186.44 and at 4.30 pm the value further increased to 203 mg/L thereafter the value declined to 183.92 at 8.30 pm which gradually increased to 207.24 mg/L at midnight. Thus Bicarbonate content of the surface water had the same trend as was found at station A.

AT SAMPLING STATION 'C'

Bicarbonate content at this site also had minimum value at 4.30 am in both the levels of water tested and the surface water generally was found to have a lower value of bicarbonates as compared to that of submerged water.

Surface water had a gradual increase in the Bicarbonate content from 4.30 am to 12.30 noon.

At 4.30 am the value obtained was 180.48 mg/L while at 8.30 am it increased to 183 mg/L and at 12.30 noon it further increased to 185 mg/L. At

4.30 pm the Bicarbonate content increased to 198.88, then it declined to 189.88 at 8.30 pm and then an increase was found at 12.30 midnight. This trend is almost similar to the surface water of sampling station A and B.

The under surface water showed similar trend in which Bicarbonate content increased from 4.30 am to 12.30 noon then declined and again gradually increased till 12.30 midnight.

At 4.30 am the value obtained was 183.72 mg/L this increased to 187.88 mg/L at 8.30 am and again the value further increased to 200.08 at 12.30 noon, this value declined to 188.56 and at 4.30 pm which gradually increased to 192.76 mg/L at 8.30 pm and to 195.68 at 12.30 midnight.

From the overall datas it can be said there was a general increase in the Bicarbonate content from 4.30 am to 12.30 noon, then a fall in the readings at 4.30 pm thereafter there was a gradual rise to a maximum values at 12.30 midnight.

9. TOTAL ALKALINITY

The Total Alkalinity followed the same trend as that observed in Bicarbonate content showing positive correlation with bicarbonate content. From 4.30 am to 12.30 noon it was more in lower level water at all sites. At 4.30 pm reversal was observed at site B and site C when Total Alkalinity was found to be more in surface water as compared to lower level water. At 8.30 pm again it was more in lower level water at all sites and a reverse trend was observed at all sites at 12.30 midnight.

The results obtained are recorded in Table XIV. Sitewise description of variation in Total Alkalinity in being given below.

AT SAMPLING STATION 'A '

At this sampling station generally the Total Alkalinity of lower level water was found to be higher than that of surface water except at 12.30 midnight when the total alkalinity of upper level water was more.

The surface water showed an increase in the amount of Total alkalinity from 4.30 am to 12.30 noon, the values being 139.70 mg/L at 4.30 am, 143.93 at 8.30 am and 154 mg/L at 12.30 noon. Thereafter at 4.30 pm the value declined to 146.16 mg/L and again an increase in value was observed till 12.30 midnight when highest value (193.70 mg/L) of total alkalinity was recorded.

The undersurface water at this site however showed a different trend and the range of variation in values of Total alkalinity was also narrow. At 8.30 am the decline in value was observed from 154 mg/L at 4.30 am to 148 mg/L. Then at 12.30 noon it again rose to 158 mg/L. At 4.30 pm it declined to 155.84 and at 8.30 pm it showed slight decrease, the value being 155.74 then at 12.30 midnight it again increased to 156.29 mg/L.

AT SAMPLING STATION 'B'

Usually the Total alkalinity was more in lower level water at this site except at two sampling stages when it was more in upper level water – at 4.30 pm and at 12.30 midnight.

From 4.30 am to 4.30 pm the Total alkalinity showed gradual increase in surface water. At 4.30 am the value recorded was 140.06 mg/L which increased to 152 at 8.30 am, 152.82 at 12.30 noon and 166.39 mg/L at 4.30 pm. At 8.30 pm the value declined to 150.75 mg/L which again increased to 169.87 mg/L at 12.30 midnight.

The undersurface water showed a different trend than that observed in the upper surface water as a zigzag trend of increase and decrease could be observed.

It increased from 142 mg/L at 4.30 am to 154.36 mg/L at 8.30 am. At 12.30 noon it further declined to 153.28 and to 150 mg/L at 4.30 pm. From 8.30 pm to 12.30 midnight it showed a gradual increase in total alkalinity with 154.92 mg/L at 8.30 pm and 158.52 mg/L at 12.30 midnight.

AT SAMPLING STATION 'C'

The Total alkalinity showed the similar trend as found in sampling station B with regard to the values in two levels of water.

The upper surface water showed a gradual increase in total alkalinity values as observed from Table XIV, from 4.30 am to 4.30 pm and then it declined at 8.30 pm and then again it increased at 12.30 midnight. The highest value observed was 163.02 mg/L at 4.30 pm and minimum value was 148.26 at 4.30 am.

The undersurface water showed an increase in total alkalinity value from 150.59 mg/L at 4.30 am to 164 mg/L at 12.30 noon. Thereafter it declined to 154.56 mg/L at 4.30 pm and then increased to 158 mg/L at 8.30 pm and 160.39 mg/L at 12.30 midnight.

10. CALCIUM CONTENT

Calcium content of water under study for diurnal variation have been collected and evaluated from the same sites and time as obtained for other contents. The values have been tabulated in the Table XIV. From these values it can be observed that there was in general a positive correlation between the bicarbonate content and the calcium content. However minimum value was obtained at 12.30 noon and maximum values obtained at 8.30 pm. These too at different stations. Analysis of datas obtained are being given below, of each sampling site seperately.

AT SAMPLING STATION 'A'

The value gradually declined from 4.30 am to 12.30 noon from 87.95 mg/L to 39.44 mg/L then at 4.30 pm its value increased to 124.47 and then again declined at 8.30 pm to 93.36 this again increased to 135.55 mg/L at 12.30 midnight thus a gradual fall was noted in the beginning with an alternate rise and fall in the succeeding samples.

The undersurface water also showed the similar trend however in general the value was higher as compared to the surface water. The values declined from 4.30 am to 12.30 noon. Then alternating rise and fall in the succeeding sample as observed in the surface water. Only at 12.30 noon the water at depth had a lower value as compared to upper level while during the rest of the sampling time the under water had a higher value.

AT SAMPLING STATION 'B'

At this sampling site the values obtained showed almost the similar trend as found at sampling station A, that is a gradual fall upto 12.30 noon thereafter rise and then again a fall in value was observed.

The surface water at 4.30 am showed calcium equal to 91.30 mg/L which decreased to 85.79 at 8.30 am. This again dropped down to 42.80 at 12.30 noon. At 4.30 pm it increased to 63.08 which again increased to 106.81 at 8.30 pm and then declined to 78.22 mg/L at midnight. At midnight this station showed a lower value as compared to that of 8.30 pm which showed a point of difference from that of station A.

The undersurface water at 4.30 am gave a value of 138.86 this decreased to 76.56 at 8.30 am and further decreased to 55.56 mg/L at 12.30 noon. At 4.30 pm it again decreased to 47.57 mg/L. Then a rise of calcium content was

noted at 8.30 pm to 110.77 mg/L which declined at midnight to 75.99 mg/L. Thus the earlier trend of calcium content variation was almost similar to that of station A while later trend was slightly different.

AT SAMPLING STATION 'C'

Station C also showed a similar trend as that found at station B i.e. decline upto 12.30 noon thereafter increase and ultimate decrease in values at the undersurface. While remained almost the same at the surface.

The surface water had a value of 92.52 mg/L at 4.30 am. This value of calcium content decreased upto 12.30 noon to 25.14 mg/L. Then rise at 4.30 pm to 110.18 mg/L. This slightly decreased at 8.30 pm to 105.97 which remained same at 12.30 midnight. The under surface value of Calcium Content in water was mostly higher as compared to that of the upper surface. However at two occasions calcium content of the lower surface was found to be less than that of the upper surface.

Calcium Content of the undersurface water had a value of 121.11 mg/L at 4.30 am. This decreased to 56.12 mg/L at 8.30 am which further decreased to 45.23 mg/L at 12.30 noon. This enhanced to 80.87 at 4.30 pm while at 8.30 pm calcium content was found to be further increased to 156.44 mg/l and then a decline to 110.77 at midnight.

In general the minimum values at different stations were found at 12.30 noon while the maximum value varied from station to station and even variation for the maximum value of Calcium Content was found at different time at different levels of water.

1. TOTAL HARDNESS

Total Hardness recorded for the water under study always gave a higher value as compared to the datas obtained for calcium content.

From the datas obtained it will be evident that the trend of Total Hardness was almost similar to the calcium content i.e. generally a higher value at depth as compared to that of surface water.

The results obtained are being mentioned below site wise.

AT SAMPLING STATION 'A'

The variation in value is similar to that, of the calcium as it showed a regular decline from 4.30 am to 12.30 noon, then a rise at 4.30 pm and a decline at 8.30 pm and again a rise at 12.30 midnight was observed.

The surface water gave a Total Hardness of 242 at 4.30 am which declined to 228 at 8.30 am and at 12.30 noon it further declined to 152 mg/L. At 4.30 pm it increased to its maximum value of 368 mg/L which declined to 264 at 8.30 pm and again increased to almost the maximum value of 366 mg/L at midnight.

The undersurface water had a Total Hardness of 206 mg/L at 4.30 am it declined to 156 mg/L at 12.30 noon. Then a rise to a maximum level of 378 at 4.30 pm and a decline to 308 mg/L at 8.30 pm and again a rise to 356 mg/L at midnight. Thus the trend is almost the same for surface as well as undersurface water with higher values of the undersurface as compared to that of the surface water except at midnight.

AT SAMPLING STATION 'B'

At this sampling station the trend for Total Hardness was found to be different for the contents of the two surfaces as compared to the sampling site

A. At half of the sampling stages upper surface gave a higher value of total hardness while reverse was found at rest of the sampling stages. However for the rise and fall the trend was almost similar.

The total hardness of the surface water gradually declined upto 12.30 noon from 4.30 am. This increased at 8.30 pm and declined at midnight. At 4.30 am the value obtained was 264 mg/L which declined to 158 mg/L at 12.30 noon increased to 196 mg/L at 4.30 pm and then further increased at 8.30 pm to 296 mg/L and declined to 228 mg/L at midnight.

AT SAMPLING STATION 'C'

At this sampling site higher value of total hardness was generally found at the lower surface as compared to the upper surface. However at two sampling stages the reverse conditions were obtained.

The upper surface value for total hardness was found to be 276 at 4.30 am which gradually declined to 104 at 12.30 noon. This increased to 310 at 4.30 pm and then a gradual decline was noted till midnight when the value obtained was 294 mg/L.

The undersurface water had a value of 344 mg/L at 4.30 am which declined to 166 mg/L at 12.30 noon then increased to 250 at 4.30 pm which further increased to 406 mg/l at 8.30 pm and a decline to 306 mg/L at midnight.

The general trend of having minimum value at 12.30 noon was found for Total Hardness also but for the maximum value difference was found for different sites and for different surfaces.

12. MAGNESIUM CONTENT

The values of Magnesium Content were found to be very less as compared to that of Calcium Content and the trends obtained also differed to that of calcium content. However mostly the values of lower surface were found to be slightly higher as compared to the upper surface.

The values obtained have been shown in Table XIV.

The values obtained have been described site wise as follows :-

AT SAMPLING STATION 'A'

At this site the Magnesium Content was more in the lower level water at three sampling stages and at the remaining stages it was higher in surface water.

The surface water at this site showed the minimum value of 6.27 at 4.30 am thereafter it showed gradual increase in value till 4.30 pm, reaching the peak value of 13.96 mg/L. The Magnesium Content started declining from 8.30 pm till 12.30 midnight, the value being 6.8 mg/L.

The undersurface water showed the same trend of gradual increase from 4.30 am to 12.30 noon. Minimum value being 7.0 mg/L, observed at 4.30 am.

At 12.30 noon it reached the peak value of 12.9 mg/L. Thereafter it gradually declined to 8.02 mg/L observed at 8.30 pm. At 12.30 midnight it showed slight increase, the value being 8.46 mg/L.

AT SAMPLING STATION 'B'

At this site the Magnesium Content was generally higher in lower level waters except at 4.30 am and 12.30 noon when reverse was obtained.

The upper surface water showed somewhat zigzag trend of rise and fall. At 4.30 am the value observed was 9.1 mg/L which declined at 8.30 am to 7.80 mg/L. It rose to 12.4 mg/L at 12.30 noon and showed gradual decline till 8.30

pm showing the value of 7.1 mg/L.Thereafter a slight rise in the value was recorded, the value being 7.97 mg/L.

The undersurface water showed a different trend as from 4.30 am to 4.30 pm a gradual increase in Magnesium Content was noted. The value observed at 4.30 am being 5.7 mg/L and at 4.30 pm it was 13.2 mg/L. At next sampling stage i.e. at 8.30 pm it declined to 7.51 and then at 12.30 midnight it again increased to 8.05 mg/L.

Thus the two levels showed a different trend of rise and fall of magnesium content.

AT SAMPLING STATION 'C'

Again at this site no particular relationship between upper level Magnesium Content and lower level Magnesium Content could be derived as at three sampling stages it was more in upper level water and at the other three it was more in the lower level water. Similarly the rise and fall in the value also showed a zigzag pattern.

The upper surface water recorded the Magnesium Content of 11 mg/L at 4.30 am and at 8.30 am it declined to 9.85 mg/L then it again increased slightly at 12.30 noon and declined to 8.5 mg/L at 4.30 pm. Thereafter it showed gradual decline till 12.30 midnight to 7.17 mg/L.

The lower level water recorded to 10.15 mg/L of Magnesium Content at 4.30 am with slight decline at 8.30 am. Then at 12.30 noon it again increased to 12.8 mg/L. It declined till 8.30 pm showing the least value of magnesium content of all the sampling sites and stages i.e. 3.75 mg/L. Then in midnight it again rose to 7.02 mg/L.

Table XIV

DIURNAL VARIATION IN PHYSICO-CHEMICAL PARAMETERS

TIME	SAMPLING STATION	TEMP.	COND	PH	CHLORIDE	D.O	B O D	FREE CO_2	BICARB	TOT.ALK	CAL	MAG	TOT. HARD
4.30 AM	A1	16	0.7	8.0	83.47	3.43	8.48	62	170.44	139.70	87.75	6.27	242
	A2	15	0.8	7.7	73.98	3.23	7.02	76	187.88	154	110.9	7.0	306
	B1	16	0.7	7.7	113.87	8.27	7.88	78	170.88	140.06	91.30	9.1	264
	B2	15	0.7	8.0	108.47	5.24	8.92	62	173.24	142	138.9	5.7	370
	C1	16	0.7	7.7	95.47	6.05	9.88	62	180.88	148.26	92.52	11	276
	C2	15	0.8	7.6	132.46	5.85	7.12	84	183.72	150.59	121.1	10.15	344
8.30 AM	A1	17	0.7	8.0	94.97	3.43	10.55	72	175.6	143.93	73.17	11.05	228
	A2	18	0.7	7.7	109.97	2.22	9.36	20	180.56	148	89.99	8.1	258
	B1	18	0.7	7.7	142.96	2.02	9.72	16	185.44	152	85.79	7.8	246
	B2	18	0.7	7.7	158.45	4.44	9.12	20	188.32	154.36	76.54	8.03	224
	C1	18	0.7	7.7	109.47	2.22	11.36	22	183	150	80.74	9.85	242
	C2	18	0.7	7.7	100.97	2.22	10.42	14	187.88	154	56.12	10.08	182
12.30 NOON	A1	18	0.7	7.7	116.96	7.86	13.12	16	187.88	154	39.44	13	152
	A2	17	0.7	7.7	156.45	3.43	11.66	14	192.76	158	41.87	12.9	156
	B1	17	0.7	7.6	56.48	9.48	11.72	18	186.44	152.82	42.8	12.4	158
	B2	16	0.8	8.0	102.98	2.22	9.44	12	187	153.28	55.56	11.08	184
	C1	19	0.7	7.5	123.46	4.44	10.12	22	185	151.64	25.14	10	104
	C2	17	0.7	7.5	90.97	1.61	8.88	26	200.08	164	45.23	12.8	166
4.30 PM	A1	19	0.7	8.0	115.96	5.24	13.45	16	178.32	146.16	124.5	13.96	368
	A2	18	0.8	7.9	124.97	4.23	11.86	16	190.12	155.84	133.7	11.27	378
	B1	20	0.7	7.9	107.47	7.66	11.84	26	203	166.39	63.08	9.39	196
	B2	19	0.7	8.2	156.45	4.03	9.12	26	183	150	47.57	13.2	174
	C1	19	0.7	7.6	127.46	5.65	13.12	16	198.88	163.02	110.2	8.5	310
	C2	18	0.7	7.6	72.48	4.03	9.48	22	188.56	154.56	80.87	11.8	250
8.30 PM	A1	19	0.7	7.6	91.47	2.82	12.11	96	183.48	150.39	93.36	7.5	264
	A2	17	0.8	7.6	109.97	6.85	10.12	122	190.0	155.74	110.2	8.02	308
	B1	18	0.7	7.5	101.47	6.05	10.81	94	183.92	150.75	106.8	7.1	296
	B2	22	0.7	7.4	105.47	6.25	9.40	154	189	154.92	110.8	7.51	308
	C1	18	0.7	7.7	94.47	5.85	12.10	120	189.88	155.64	106	8.14	298
	C2	19	0.7	7.7	103.97	6.23	8.08	146	192.76	158	156.4	3.75	406
12.30 MIDNIGHT	A1	16	0.7	7.6	125.46	2.82	9.56	180	236.32	193.70	135.6	6.81	366
	A2	17	0.8	7.4	119.46	1.81	7.22	364	190.68	156.29	128.7	8.46	356
	B1	18	0.7	7.5	116.46	2.82	8.12	186	207.24	169.87	78.22	7.97	228
	B2	15	0.7	7.3	121.46	3.83	9.24	232	193.40	158.52	75.99	8.05	222
	C1	17	0.7	7.7	123.96	4.23	10.82	204	198.36	162.59	106	7.17	294
	C2	15	0.7	7.5	152.93	4.23	7.56	282	195.68	160.39	110.8	7.02	306

SECTION - 5

QUANTITATIVE AND QUALITATIVE DYNAMISM OF PLANKTONIC POPULATION

A. PHYTO PLANKTON STUDY

B. PRIMARY PRODUCTIVITY.

SECTION –5 CHAPTER – A

PHYTOPLANKTON STUDY

Aquatic Ecosystem is a complex system by itself constituted by various biotic and abiotic components. Every water body represents seperate structural composition as every water body exhibits its own peculiarities with regard to its flora, fauna and physico-chemical characteristics. In the aquatic ecosystem phytoplanktons constitute important basis for nutritional cycle.

The phytoplanktons consist of an assemblage of small microscopic plants having no or very limited power of locomotion. The abundance of plankton is dependent on several physicochemical characteristics of water and can be used as indicator of trophic status of water body. (Govind 1963, Varma and Dutta 1987, Munshi 1987).

Algae the major constituent of the planktonic population are ubiquitous and abound in almost all type of water bodies.

In comparison to natural undisturbed freshwater systems phytoplanktons in polluted waters are exposed to different environmental stress and a study on the biological parameters of such water bodies certainly paves way for future waste treatment programme with prior knowledge of indicator species.

Venkateshwarlu et al (1994) used algal species as indicators of pollution gradient. Increase in pollution inturn reduces the algal species diversity.

Different phytoplankton groups have been used to evaluate the trophic status and pollution potential of freshwater bodies. Nygard (1949) infact

proposed 5 indices to evaluate organic pollution of water bodies on basis of algal population. Palmer (1967) also proposed certain index on basis of composit rating of algae tolerating organic pollution.

Abundant algal growth was considered to be an indicator of Eutrophication. (Kumar et al and Zutshi 1976 and Pant et al 1980). Various workers had reported the presence of members of Chlorophyceae, Cyanophyceae and Bacillariophyceae in water bodies which contain organic matter as pollutant eg. S. Kaushik, M.S. Agarkar and D.N. Saksena 1991; Patil et al 1983; S.S. Patil, D.B. Singh and D.K. Harshey 1983, Desai 1987. Diatoms however have been reported to dominate the clean water body. (Trivedy et al 1985).

In the present study of 'Pani Ki Dharamshala Reservoir' water samples were collected from different parts of the Reservoir and quantitative and qualitative studies were done from composite samples thus obtained. The method followed was as described in Section-2 – Materials and Methods. Monthly observations were recorded in Tables XV A and XVI.

QUANTITATIVE ANALYSIS OF DIFFERENT GROUPS

During the beginning of the study period the water body had few macrophytes and patches of azolla and algal scums along with suspended organic matter. Gradually the Ipomoea species started spreading along with other macrophytes. Ultimately the macrophytic coverage became so dense by the end of the study period (last 5 months) the water surface was barely visible. During this period the number of planktons reduced both in number and species diversity.

During the present study 18 genera belonging to different groups were obtained. The different phytoplankton groups recorded were as follows in increasing order :-

(Euglenophyceae < Bacillariophyceae < Cyanophyceae < Chlorophyceae)

OF the 18 genera indentified, 8 genera belong to **Chlorophyceae,** 6 genera to **Cyanophyceae**, 3 to **Bacillariophyceae** and 1 to **Euglenophyceae.** Though the number of genera belonging to Chlorophyceae were more than those of Cyanophyceae, but the total number or count of cells / L of Cyanophycean members were usually found to be higher during every month than those of chlorophyceae.

Members belonging to Chlorophyceae Cyanophyceae and Bacillariophyceae were found to be present throughout the study period while Euglenophyceae were generally present during winter months but could not be observed during the months-March, May, June, July and August 2000.

It was observed that during Winter season total population of members of Chlorophyceae, Cyanophyceae and Euglenophyceae was usually higher as compared to that found in other seasons. The total count of cells/L being :-

47×10^3 cells / L in **Chlorophyceae;** 73×10^3 cells/L in **Cyanophyceae** and 13×10^3 cells/L in **Euglenophyceae.**

The **Bacillariophycean** total count was however highest in summer months 39×10^3 cells / L.

The **Chlorophycean** members' total count of population was usually higher in Rainy Season than that found in Summer season. However total count of **Cyanophyceae** and **Bacillarophyceae** was usually more in Summer

season as compared to rainy season. **Euglenophyceae** also showed higher count in rainy season than in summer season. Infact they were usually absent in most of the summer period (except in April 2000). During initial phase of Rainy season also the **Euglenophycean** count was zero.

Monthly observations recorded in Table XV. A show that the **Chlorophyceae** had highest count in October 99 (23 x 10^3 cells/L), then it generally declined till February 2000 and showed increase in count till April 2000. Thereafter the total count again declined. During the last 3 months of the study period the count nearly remained same and infact represented their lowest count – 4 x 10^3 cells/L.

The group **Cyanophyceae** also showed the highest count in October 99 (25 x 10^3 cells/L). Then there was drop in total count of Cyanophycean members till January 2000, then increased in February and March 2000 to 18 x 10^3 cells/L and 19 x 10^3 cells/L respectively. The count dropped to 18 x 10^3 cells per L in April 2000 and again it increased to 20 x 10^3 cells/L in May 2000. Thereafter it again declined to 7x10^3 in July 2000 and August 2000. In September 2000 it again increased to 16x10^3 cells/L.

The **Bacillariophyceae** showed its highest population in March 2000 as the highest count was observed in this month – 13 x 10^3 cells/L. From the beginning of the study period that is October 99 (11 x 10^3 cells/L) the total count showed gradual decline till January 2000, lowest count being recorded in this month i.e. 4 x 10^3 cells/L. It increased in February 2000 and in March 2000 the population further increased. Thereafter it declined till July 2000, value being 5 x 10^3 cells/L. In August 2000 the total count was same which again increased to 7 x 10^3 cells/L in September 2000.

The total count of population of class **Euglenophyceae** was highest in November 99 – 5 x 10^3 cells/L. Thereafter it declined till February 2000 (1 x 10^3 cells/L). No member of this group was present in the five months of March, May, June, July and August 2000. The member of this group reappeared in September 2000 with the total count of 1x 10^3 cells/L.

SPECIES DIVERSITY

Generic variations among members of phytoplankton belonging to different groups is being given below :-

CHLOROPHYCEAE

The genera obtained are Ankistrodesmus, Chlamydomonas, Chlorella, Cosmarium, Scenedesnus, Spirogyra, Pediastrum and Closterium. However none of the genera appeared throughout the study period.

1. ANKISTRODESMUS FALCATUS

The cells are usually needle shaped and are found singly, sometimes in bundle. The cells possess a single parietal chloroplast occupying the greater part of the length of cells, with or without pyrenoids.

Its number was usually high in October 99 (4 x 10^3 cells/L). Thereafter its number was observed to decrease during the winter months reaching 1 x 10^3 cells/L in March. No cells of this genera could be observed in the three summer months – April, May, June 2000. In July i.e. with the advent of rainy season it again appeared, the count being 1 x 10^3 cells/L. It again could not be detected in August 2000 but reappeared in September 2000 (1 x 10^3 cells/L).

2. CHLAMYDOMONAS ANGULOSA

The cells are usually oblong or ovoid in shape with two equal flagella arising anteriorly. The chloroplast is usually cup shaped with single pyrenoid embedded in thick basal portion. Two contractile vacuoles are generally situated in anterior colourless cytoplasm.

Its number throughout the study period was low and found only in five months. The total count of this genera remained same in October 99, November 99 and December 99 – 2 x 10^3 cells/L. From January 2000 to July 2000 it was absent. The cells again reappeared in August 2000, the total count being 3 x 10^3 cells/L. In the last month of the study period i.e. September 2000 the total count reduced to 1 x 10^3 cells/L.

3. CHLORELLA VULGARIS

The cells are small spherical and green coloured. These cells are non motile and found solitary. The chloroplast is usually cup shaped. The cells of this genera could be observed in the first seven months of the study period. (From October 99 to April 2000). During the later part of the study period it was absent (from May 2000 to September 2000). In October 99 the total count was found to be highest i.e. 4 x 10^3 cells/L, thereafter it declined till January 2000 to 1 x 10^3 cells/L. In February, March and April 2000 the total count was approximately same i.e. 1 x 10^3 cells/L.

4. COSMARIUM GRANATUM

These are represented by free floating solitary small flat cells. The cells were found intermingled with strands of other algal forms sometimes found

even along the walls of the Reservoir. The unicell has deep median constriction with the granulated cell wall.

The occurrence of this genera was rather uneven. It was observed to be present in highest number in October 99 and November 99 – 3 x 10^3 cells/L. In December 99 the count declined to 1 x 10^3 cells/L. It could not be detected in January and February 2000. The cells of this genera again reappeared in March and April 2000 with the count being 1 x 10^3 cells/L. It was absent in May 2000 and August 2000. In June 2000 it reappeared, the total count being 2 x 10^3 cells/L. In July and September 2000 the count reduced to 1 x 10^3 cells/L.

5. SCENDESMUS

The cells were found in groups i.e. in colony form. The colony, termed as coenobium is flat plate of fusiform cells. Chloroplast is single, laminate containing one pyrenoid.

Though it is said to be widely distributed in standing waters its count in this water did not exceed to total count of other genera and was restricted to the range of 1 x $10^3$to 3 x 10^3 cells/L. It was present in winter season and disappeared with the advent of summer season, with occasional appearance in May 2000 and thereafter till the end of study period it was absent. Highest count (3 x 10^3 cells/L) was recorded in November 99, it declined to 1 x 10^3 cells/L in December 99. The count remained same till February and increased in March 2000 to 2 x 10^3 cells/L.

6. SPIROGYRA

The strands were free floating and found in masses. It is usually called pond scum. The thallus consist of long green cylindrical threads. The cells are

cylindrical characterised by green, helical band of chloroplasts, which runs in spiral manner within the cell and occupies parietal position.

In the beginning of the study period that is in October 99 it showed the total count of 3 x 10^3 cells/L. The number declined in November 99 but in December 99 it was found to be in abundance with total count 7 x 10^3 cells/L. Its number declined in January 2000 and February 2000 to 2 x 10^3 cells/L, in March 2000 it further reduced to 1 x 10^3 cells/L. The number of cells increased in April and May 2000 to 4 x 10^3 cells/L. Thereafter in June 2000 it declined to 1 x 10^3 cells/L. The cells could not be observed in two months of rainy season i.e. July and August 2000. It reappeared in September 2000 with the total count being 1 x 10^3 cells/L.

7. PEDIASTRUM SIMPLEX

It is non motile coenobial algae comprising of stellate free floating colonies. 7 to 64 polygonal cells are arranged in single layer.

It was of common occurance in the Reservoir during three of the summer months April, May and June 2000.

In the early part of the study period i.e. since October 99 to December 99 the total count was 1 x 10^3 cells/L. It was absent in January and February 2000 and reappeared in March (1 x 10^3 cells/L). It was not recorded in September 2000.

8. CLOSTERIUM EHRENBERGII

The elongated cells, tapering from middle towards the ends are found solitary, usually mixed with slime.

The highest number was recorded in October 99 i.e. 4 x 10^3 cells/L. Then it declined to 3 x 10^3 cells/L in November 99 and further decreased to 1 x 10^3 cells/L in December 99 and January 2000. It was not observed in February 2000 but reappeared in March 2000 and April 2000 with the count of 1 x 10^3 cells/L. Again in May and June 2000 it was absent. In July 2000 its count was 1 x 10^3 and again could not be detected in August and September 2000.

CYANOPHYCEAE

The genera recorded are – Alphanocapsa, Chroococcus, Merismopedia, Oscillatoria, Phormedium and Microcystis of these Oscillatoria was frequently obtained and was the dominant genera throughout the study period.

1. APHANOCAPSA

Thallus is gelatinous, homogenous with free spherical cells loosely arranged.

Usually observed in the water samples of the reservoir for most of the study period except for June and August 2000 when it was absent. Highest count was observed in May 2000 – 6 x 10^3 cells/L. In the beginning of the study period i.e. in October 99 the total count recorded was 5 x 10^3 cells/L thereafter it declined in November 99 to 3 x 10^3 cells/L and the count increased slightly in December 99 to 4 x 10^3 cells/L, thereafter declining to 1 x 10^3 cells per L in January 2000. Sudden rise in number was recorded in February 2000 (3 x 10^3 cells/L) then again in March 2000 and April 2000 a drop to 1 x 10^3 was noticed. In May the peak value of count was recorded and disappeared in the early rainy season with occasional appearance in July 2000 (1 x 10^3) and September 2000 – 4 x 10^3 cells/L.

2. CHROOCOCCUS

Simplest forms observed free floating or intermingled with other algal forms of Cyanophyceae and Chlorophyceae. Usually single cells are found sometimes in colonies of 2 - 4 cells, which may be bluish green or yellowish. Cells are covered by lamellated sheath. Cells may be spherical or hemispherical sometimes flattened. Cytoplasm contains a central body called incipient nucleus.

The total count usually varied from 1×10^3 to 2×10^3 cells/L throughout the study period. Total count of 2×10^3 cells was recorded in October 99 and April 2000 while during the remaining months when it was present its count was 1×10^3 cells/L (November, December 99, March 2000, May 2000 June 2000 and September 2000. It was absent in January 2000, July and August 2000.

3. MERISMOPEDIA PUNCTATA

These are colonial forms where cells are embedded in gelatinous matrix as individual cell sheaths fuse. The colony is flat plate of cells as division takes place alternately in two planes.

Its number was usually higher in early winter season. Infact it was dominant in October 99 as highest count was recorded in this month i.e. 8×10^3 cells/L. In the next two months the count declined to 7×10^3 cells/L. It **further declined gradually till February 2000 to 2×10^3. In March 2000 it** showed a sudden rise in the count to 5×10^3 cells/L, thereafter declining to 2×10^3 cells/L in April and May 2000. Then it disappeared in June and July. It

reappeared in August 2000 (1×10^3 cells/L) and was again absent in September 2000.

4. OSCILLATORIA

Patches of entangled masses found floating. Grows luxuriantly in stagnant water.

Trichomes are long, thread like unbranched structures, sheath around it is poorly developed. These are septate, septa are often marked by rows of granules present on either side. All the cells are similar in structure.

It was abundant and found in the reservoir throughout the study period. The highest count was 9×10^3 in Nov. 99 and February 2000. The values decreased in December 99 and January 2000 to 5×10^3 and 4×10^3 cells/L respectively. In March the total count observed was 7×10^3 cells/L, it slightly increased in April 2000 to 8×10^3 cells/L, it again declined in May to 7×10^3 and reached to 8×10^3 cells/L in June 2000. In August & September 2000 gradual increase was observed to 5×10^3 cells/L, 8×10^3 cells/L respectively.

5. PHORMEDIUM

Trichomes of this genera appear nearly similar to oscillatoria, however the filaments are often agglutinated with one another. Cells are longer than broad.

The total count in the early part of the study period was usually low i.e .1×10^3 cells/L during October, November rand December 99 and January 2000. It then increased gradually from February 2000 to April i.e. 2×10^3 to 4×10^3 cells/L. In May it again declined to 1×10^3 cells/L and thereafter it was absent for the remaining study period i.e. till September 2000.

6. MICROCYSTIS AERUGINOSA

Irregular colonies with illdefined sheath. Usually found free floating. Cells are spherical small and irregularly arranged. Its count was comparatively low in this reservoir.

The total count usually varied from 1 x 10^3 to 4 x 10^3 cells/L with no regular trend of increase or decrease in total count seasonally.

EUGLENOPHYCEAE

1. Euglena sp. – the cells of Euglena are unicellular free swimming green coloured & uniflagellate Posterior end is some what pointed the cell has many chloroplasts.

Usually for most of the time its total count was low i.e. 1 x 10^3 cells/L. The highest count was recorded in November 99 i.e. 5 x 10^3 cells/L. In December 99 it reduced to 3 x 10^3 cells/L. In January 2000 it increased to 4 x 10^3 cells/L then again declined to 1 x 10^3 in February 2000. It was absent in March, reappearing in April 2000 (1 x 10^3 cells/L) then again it was absent from May 2000 to August 2000 and reappeared in September 2000 with count of 1 x 10^3 cells/L.

BACILLARIOPHYCEAE

Only 3 genera could be identified – Pinnularia, Navicula and Synedra. Navicula was recorded throughout the study period.

1. PINNULARIA VIRIDIS

Thallus is a diploid unicell. General form is like an oblong box. The frustules (the diatom cell) are symmetrical. Axial field broad and next to

central and polar nodules. The valve is isobilateral with only 2 planes of symmetry and have smooth transverse costae. It appears rectangular in girdle view, girdle is smooth without intercalary bands.

The total count did not vary much throughout the study period. It was highest during the beginning of the study period i.e. in October 99 it was 4 x 10^3 cells/L thereafter it declined till January 2000 to 1 x 10^3 cells/L. In February and March 2000 total count was 2 x 10^3 cells/L. In April 2000 and May 2000 it w as again 1 x 10^3 cells/L. It was absent in June, August and September 2000.

1. NAVICULA RADIOSA

It is freshwater pennate diatom. It is boat shaped in valve view. It comprises of symmetrical frustules. Raphe and axial field straight. Have a single chromatophore apposed to one of the valves and spreading on to two girdles.

This diatom was present throughout the study period. The highest count was 7 x 10^3 cells/L observed in September 2000. Since the beginning of the study period i.e. October 99 the count gradually reduced during the winter months till February 2000 (from 6 x 10^3 to 1 x 10^3 cells/L in Feb). In March it again increased to 5 x 10^3 cells/L. It further increased to 6 x 10^3 cells/L in April and in May 2000 reduced to 5 x 10^3 cells/L thereafter showed a gradual decline till July 2000 (3 x 10^3 cells/L). In August 2000 the count increased to 5 x 10^3 cells/L and in September 2000 it increased to the peak value 7 x 10^3 cells/L.

3. SYNEDRA AFFINIS

It is needle shaped pennate form in which the two systems of striae are seperated by a narrow linear smooth area (axial area) devoid of markings and occupying apical axis of the valve. This smooth area is called pseudo raphe. Sometimes axial area widens in Centre and also at poles of valve forming false nodules.

During the study period it was not found in December 99, July 2000, August 2000 and September 2000.

The highest count was 6 x 10^3 cells/L recorded in March 2000. In the beginning of the study period the count was very low i.e. 1 x 10^3 cells/L, it increased to 2 x 10^3 cells/L in November and disappeared in December 99. In January it appeared again the count being 1 x 10^3 cells/L which increased gradually till March 2000 to 6 x 10^3 cells/L. Thereafter till June it decreased gradually and did not appear in the last 3 months of the study period.

Table XVA

MONTHLY VARIATION IN TOTAL POPULATION OF DIFF. PHYTO. GRPS IN THOUSAND

Months	Chlorophyceae	Cyanophyceae	Bacillariophyceae	Euglenophyceae
Oct. 99	23	25	11	1
Nov. 99	19	23	8	5
Dec. 99	17	19	5	3
Jan. 2000	6	13	4	4
Feb. 2000	5	18	6	1
Mar.2000	8	19	13	-
Apr. 2000	10	18	12	1
May.2000	9	20	7	-
Jun.2000	6	13	7	-
Jul.2000	4	7	5	-
Aug. 2000	4	7	5	-
Sept. 2000	4	16	7	1

Fig -14 Monthly Variation in Total Population of diff. Phyto. Grps.

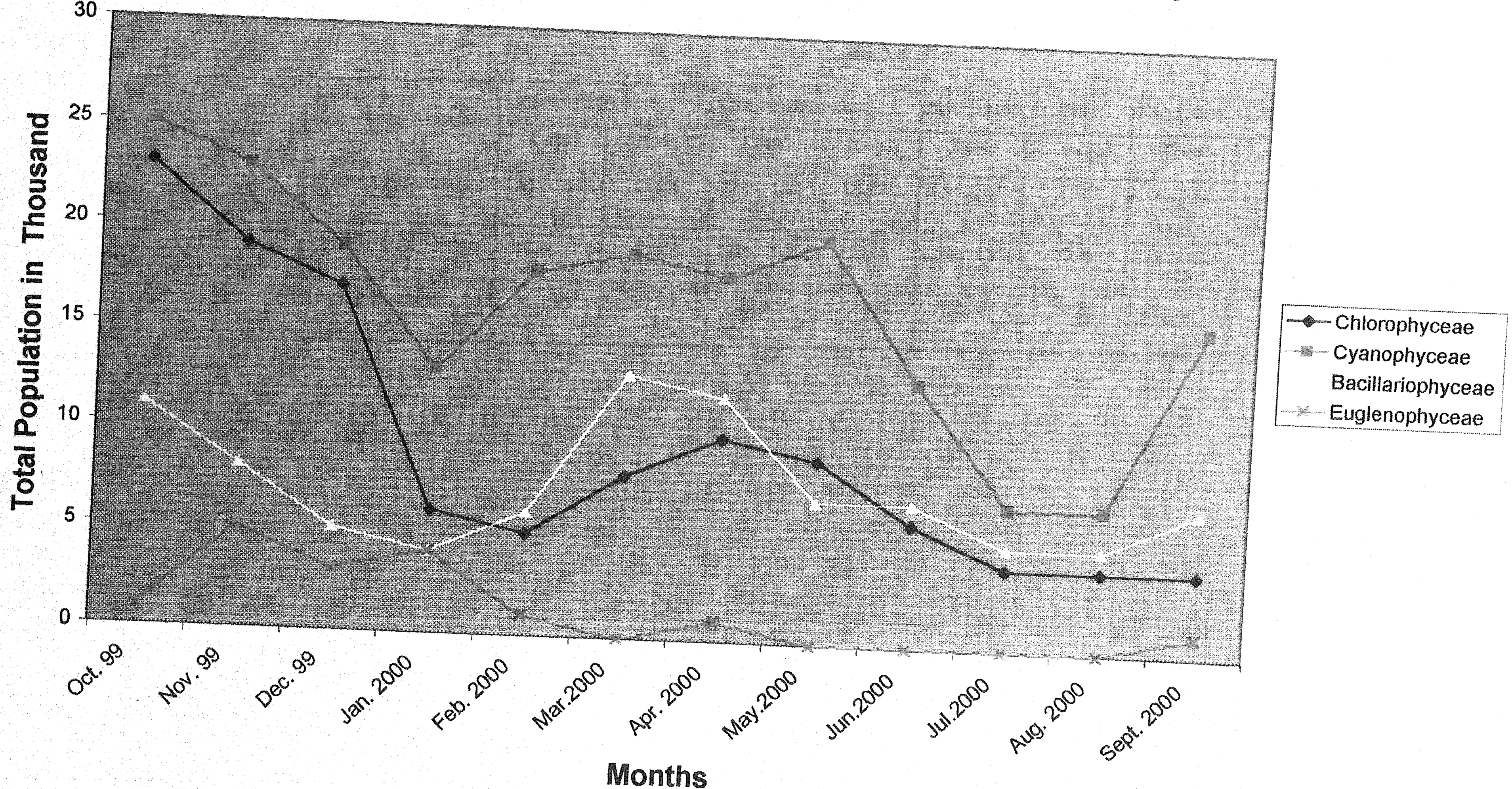
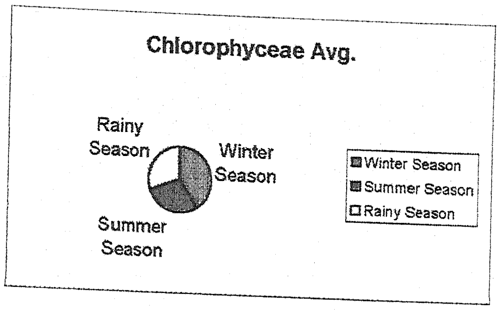
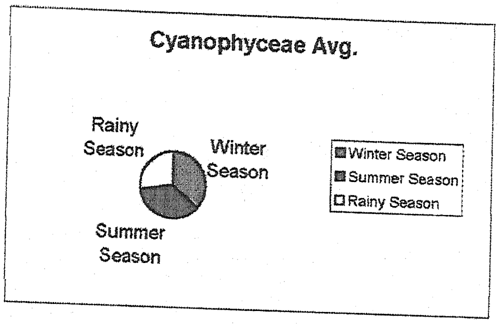


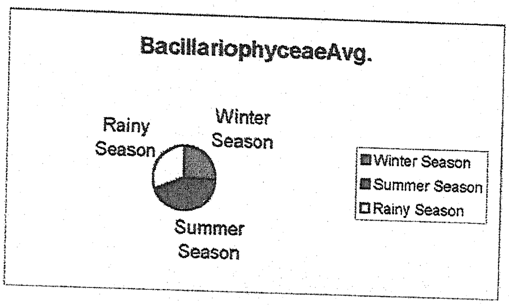
Table XV B

Seasons	Chlorophyceae		Cyanophyceae		Bacillariophyceae		Euglenophyceae	
	Total	**Avg.**	**Total**	**Avg.**	**Total**	**Avg.**	**Total**	**Avg.**
Winter Season	47×10^3	11750	73×10^3	18250	23×10^3	5750	13×10^3	3250
Summer Season	33×10^3	8250	70×10^3	18250	39×10^3	9750	1×10^3	250
Rainy Season	35×10^3	8750	55×10^3	13750	28×10^3	7000	2×10^3	500

Fig 15 Seasonal Variation in Different Algal Groups







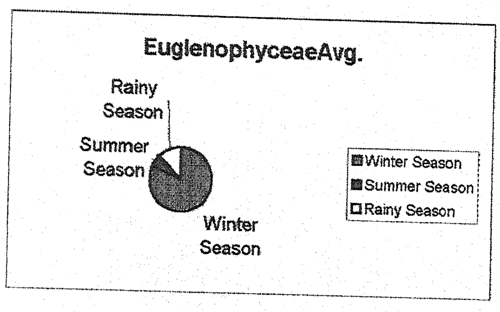
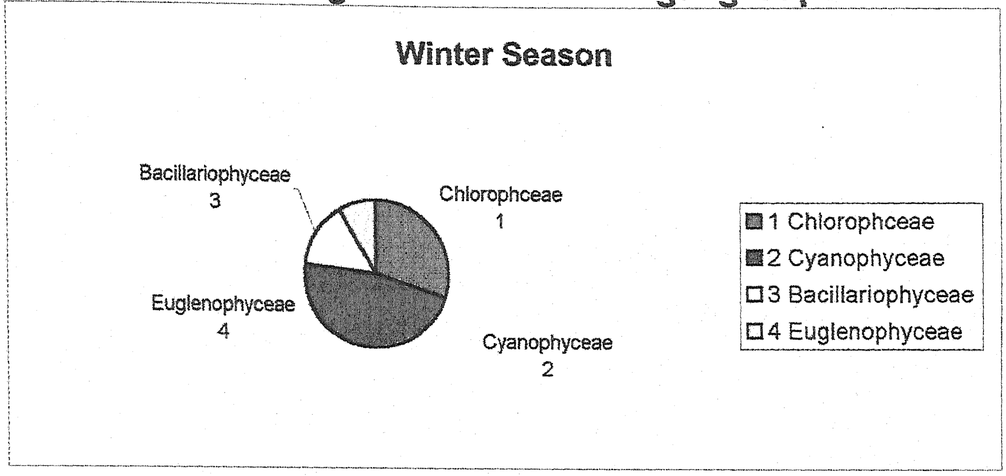
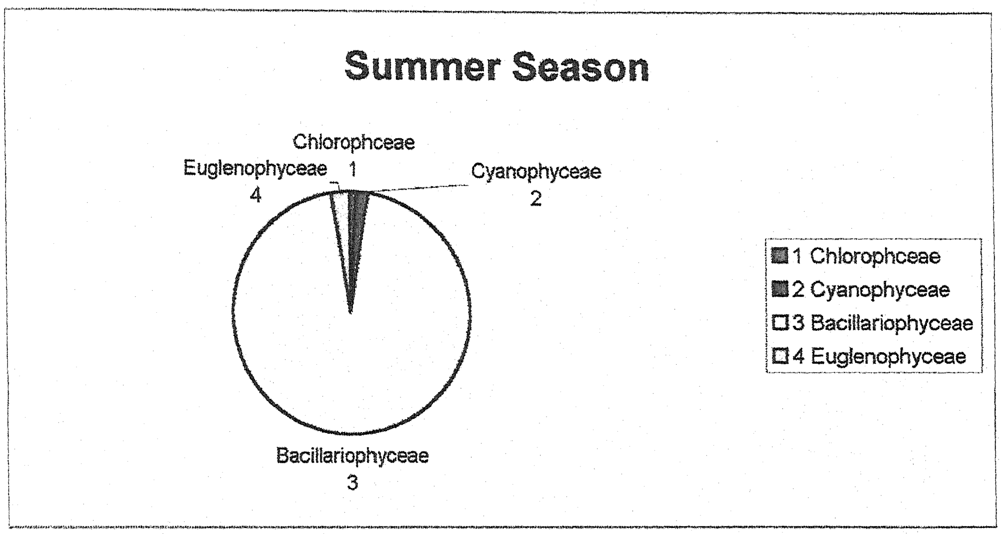


Fig -16 Percentage abundance of Algal groups.





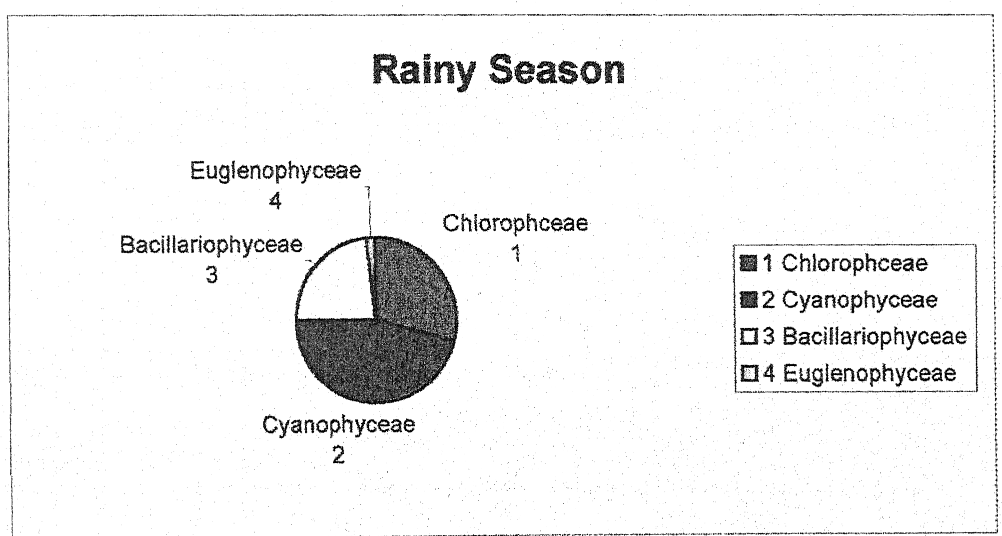


TABLE XVI MONTHLY POPULATION OF ALGAL FORMS

(Calculated according to Green berg – Sedgwick Rafter Cell (No/L))

S.No.	ALGAL GENERA	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00
	CHLOROPHYCEAE												
1	Ankistrodesmus	4×10^3	3×10^3	2×10^3	1×10^3	1×10^3	1×10^3	-	-	-	1×10^3	-	1×10^3
2	Chlamydomonas	2×10^3	2×10^3	2×10^3	-	-	-	-	-	-	-	3×10^3	1×10^3
3	Chlorella	4×10^3	3×10^3	2×10^3	1×10^3	1×10^3	1×10^3	1×10^3	-	-	-	-	-
4	Cosmarium	3×10^3	3×10^3	1×10^3	-	-	1×10^3	1×10^3	-	2×10^3	1×10^3	-	1×10^3
5	Scendesmus	2×10^3	3×10^3	1×10^3	1×10^3	1×10^3	2×10^3	-	1×10^3	-	-	-	-
6	Spirogyra	3×10^3	1×10^3	7×10^3	2×10^3	2×10^3	1×10^3	4×10^3	4×10^3	1×10^3	-	-	1×10^3
7	Pediastrum	1×10^3	1×10^3	1×10^3	-	-	1×10^3	3×10^3	4×10^3	3×10^3	1×10^3	1×10^3	-
8	Closterium	4×10^3	3×10^3	1×10^3	1×10^3	-	1×10^3	1×10^3	-	-	1×10^3	-	-
	CYANOPHYCEAE												
9	Aphanocapsa	5×10^3	3×10^3	4×10^3	1×10^3	3×10^3	1×10^3	1×10^3	6×10^3	-	1×10^3	-	4×10^3
10	Chroococcus	2×10^3	1×10^3	1×10^3	-	-	1×10^3	2×10^3	1×10^3	1×10^3	-	-	1×10^3
11	Merismopedia	8×10^3	7×10^3	7×10^3	4×10^3	2×10^3	5×10^3	2×10^3	2×10^3	-	-	1×10^3	-
12	Oscillatoria	8×10^3	9×10^3	5×10^3	4×10^3	9×10^3	7×10^3	8×10^3	7×10^3	8×10^3	4×10^3	5×10^3	8×10^3
13	Phormedium	1×10^3	1×10^3	1×10^3	1×10^3	2×10^3	4×10^3	4×10^3	1×10^3	-	-	-	-
14	Microcystis	1×10^3	2×10^3	1×10^3	3×10^3	2×10^3	1×10^3	1×10^3	3×10^3	3×10^3	2×10^3	1×10^3	3×10^3
	EUGLENOPHYCEAE												
15	Euglena	1×10^3	5×10^3	3×10^3	4×10^3	1×10^3	-	1×10^3	-	-	-	-	1×10^3
	BACILLARIOPHYCEAE												
16	Pinnularia	4×10^3	2×10^3	1×10^3	1×10^3	2×10^3	2×10^3	1×10^3	1×10^3	-	2×10^3	-	-
17	Navicula	6×10^3	4×10^3	4×10^3	2×10^3	1×10^3	5×10^3	6×10^3	5×10^3	4×10^3	3×10^3	5×10^3	7×10^3
18	Synedra	1×10^3	2×10^3	-	1×10^3	3×10^3	6×10^3	5×10^3	1×10^3	3×10^3	-	-	-

TABLE XVII

SN.	Genera	Frequency	Density	Abundance
	Chlorophyceae			
1	Ankistrodesmus	66.67%	1166.63	17 50
2	Chlamydomonas	41.67%	833.3	2000
3	Chlorella	58.30%	1083.33	1857.14
4	Cosmarium	66.67%	1083.33	1625
5	Scenedesmus	58.30%	916.6	1571.43
6	Spirogyra	83.33%	2166.67	2600
7	Pediastrum	75%	1333.33	1777.78
8	Closterium	58.33%	1000	1714.29
	Cyanophyceae			
9	Aphanocapsa	83.33%	2416.67	2900
10	Chroococcus	66.67%	833.3	1250
11	Merismopedia	75%	3166.67	4222.22
12	Oscillatoria	100%	6833.33	6833.33
13	Phormedium	66.67%	1250	1875
14	Microcystis	75%	1333.33	1777.78
	Euglenophyceae			
15	Euglena	58.30%	1333.33	2285.71
	Bacillariophyceae			
16	Pinnularia	75%	1333.33	1777.78
17	Navicula	100%	4333.33	4333.33
18	Synedra	66.67%	1833.33	2750

SECTION –5 CHAPTER ‘B’

PRIMARY PRODUCTIVITY

Limnological studies has received greater attention during past decades. The ever increasing exploitation of freshwater bodies by man is inturn increasing the pollution level and Eutrophication. This affects the productivity of fresh waters. Primary productivity of phytoplanktons is also now an important aspect of limnological studies.

“Productivity is defined as the rate of carbon assimilation per unit volume in per unit time” – as it is an ultimate outcome of photosynthesis. It makes chemical energy and organic matter available to entire biological community.

Primary productivity of Indian water bodies have been studied by many workers extensively. To mention a few are – Ganpati and Sreenivasan (1968, 1970, 1972), Khan and Zutshi (1979), Adoni (1975), A.D. Adoni and Sarkar (1985) S.R. Mishra and D.N. Saksena (1992).

During the present study the rate of primary production was measured by Light and Dark Bottle method of Gaarder and Gran (1927). Dissolved oxygen was determined by Winkler’s modified azide method. From the changes in oxygen concentration in light and dark bottles Gross Primary Productivity, Net Primary Productivity and Respiration rates were calculated. The carbon values (gC / m^3 / day) were obtained from oxygen values by multiplying with factor 0.375 (West lake 1963; Sreenivasan 1964 a; A.D. Adoni 1982).

During the present study GPP varied from 0.188 to 4.534 gC/m^3 / day. Monthly variation did not show any regular pattern of increase and decrease. The fluctuations observed were quite significant.

The changes in the climatic and environmental conditions affect the surface waters more markedly hence greater amplitude of variation in the productivity was observed (as also worked out by H.M. Saran and A.D. Adoni 1985).

While studying the seasonwise changes it was observed that Gross Primary Productivity of this reservoir was found to be greatest in summer season, followed by winter and rainy season. However the peak value was observed during winter season– in January 2000, the value being 4.534 $gC/m^3/d$. The highest value recorded during the summer season was 2.798 $gC/m^3/day$. The value is lower than the peak value obtained in winter season but sum of GPP and average recorded in summer season was however greater. The highest value recorded during rainy season was 1.815 $gC/m^3/day$.

Similar trend of variation in Net Primary Productivity was observed. The NPP of Reservoir ranging from 0.113 (December 99 first fortnight) to 3.476 (January 2000 first fortnight) $gC/m^3/day$. Seasonal variation also showed similar trend as that found in GPP i.e. highest average values were obtained in summer season 0.873 $gC/m^3/d$ followed by winter season 0.860 $gC/m^3/d$ and lowest in rainy season 0.7 06 $gC/m^3/day$.

Respiration is heterotrophic activity of Phytoplanktons, Zooplanktons, bacteria and fungi etc. inhabiting the lake water. The respiration rate values varied from 0.075 $gC/m^3/d$ (December 99 first fortnight) to 1.961 $gC/m^3/d$. (February 2000 first fortnight).

The ratio of NPP:GPP varied from 0.22 to 0.77. The average seasonal ratio was highest in Rainy season – 0.56 and was minimum in winter season 0.41. In summer season the average NPP:GPP ratio was 0.45.

The total annual GPP obtained was 40.646. Thus according to the categorisation as GPP is < 100, it can be said that the Reservoir belongs to Oligotrophic category.

From the fig. XVIII plotted for the monthwise GPP and NPP it can be observed that the values regularly showed fortnight fluctuations. The entire graph shows a zigzag pattern.

During the initial stage GPP started with an average value of 1.5 $gC/m^3/d$ it then decreased in the second fortnight and further decreased in first fortnight of November to a value of 0.338 $gC/m^3/d$. In the second fortnight of November the value reached its original mark and then during the first fortnight of December it reached to its minimum value of 0.188 $gC/m^3/d$. It increased slightly in the second fortnight of December 99 and then reached the maximum level in first fortnight of January 2000 – 4.534 $gC/m^3/d$ then in the second fortnight a sharp decline was noticed i.e. from 4.534 $gC/m^3/d$ the value reduced to 1.738 $gC/m^3/d$. Again in the first fortnight of February the second highest value was observed i.e. 3.78 $gC/m^3/d$. In the 2nd fortnight of February the value again declined to 1.665 $gC/m^3/d$ there after fluctuations were obserbed but not too sharp as observed during winter months .

The 3rd highest value of GPP was observed in the first fortnight of May i.e. 2.797 $gC/m^3/d$.

The values of NPP showed a similar trend and always remained less than the GPP.

The Respiratory rate was found to be lowest during December 99 and January 2000, and was found to be maximum during April and May.

TABLE-XVIII A

THE GROS PRIMARY PRODUCTIVITY, NET PRIMARY PRODUCTIVITY & RESPIRATION RATE IN PANI KI DHARAMSHALA RESERVOIR (1999-2000).

Months	GPP gc/m^3/d	NPP gc/m^3/d	Respiration Rate	NPP : GPP
Oct. 99 I	1.522	0.491	1.031	0.33
II	1.057	0.341	0.716	0.32
Nov. 99 I	0.338	0.075	0.263	0.22
II	1.522	0.491	1.031	0.32
Dec. 99 I	0.188	0.113	0.075	0.6
II	0.562	0.206	0.356	0.37
Jan. 2000 I	4.534	3.476	1.058	0.77
II	1.738	0.36	1.378	0.21
Feb. 2000 I	3.78	1.819	1.961	0.48
II	1.665	0.739	0.926	0.38
March2000 I	1.287	0.784	0.503	0.61
II	2.269	1.031	1.238	0.45
April 2000 I	1.133	0.739	0.394	0.65
II	2.115	0.371	1.744	0.18
May 2000 I	2.798	1.196	1.601	0.43
II	2.569	0.874	1.695	0.34
June 2000 I	2.262	1.249	1.013	0.55
II	0.833	0.544	0.289	0.65
July 2000 I	1.362	0.664	0.698	0.49
II	1.588	0.838	0.742	0.53
Aug. 2000 I	1.816	1.013	0.803	0.56
II	0.987	0.574	0.413	0.58
Sept. 2000 I	0.983	0.799	0.184	0.81
II	1.437	0.728	0.709	0.51

Fig -17 Monthly Variation In GPP & NPP

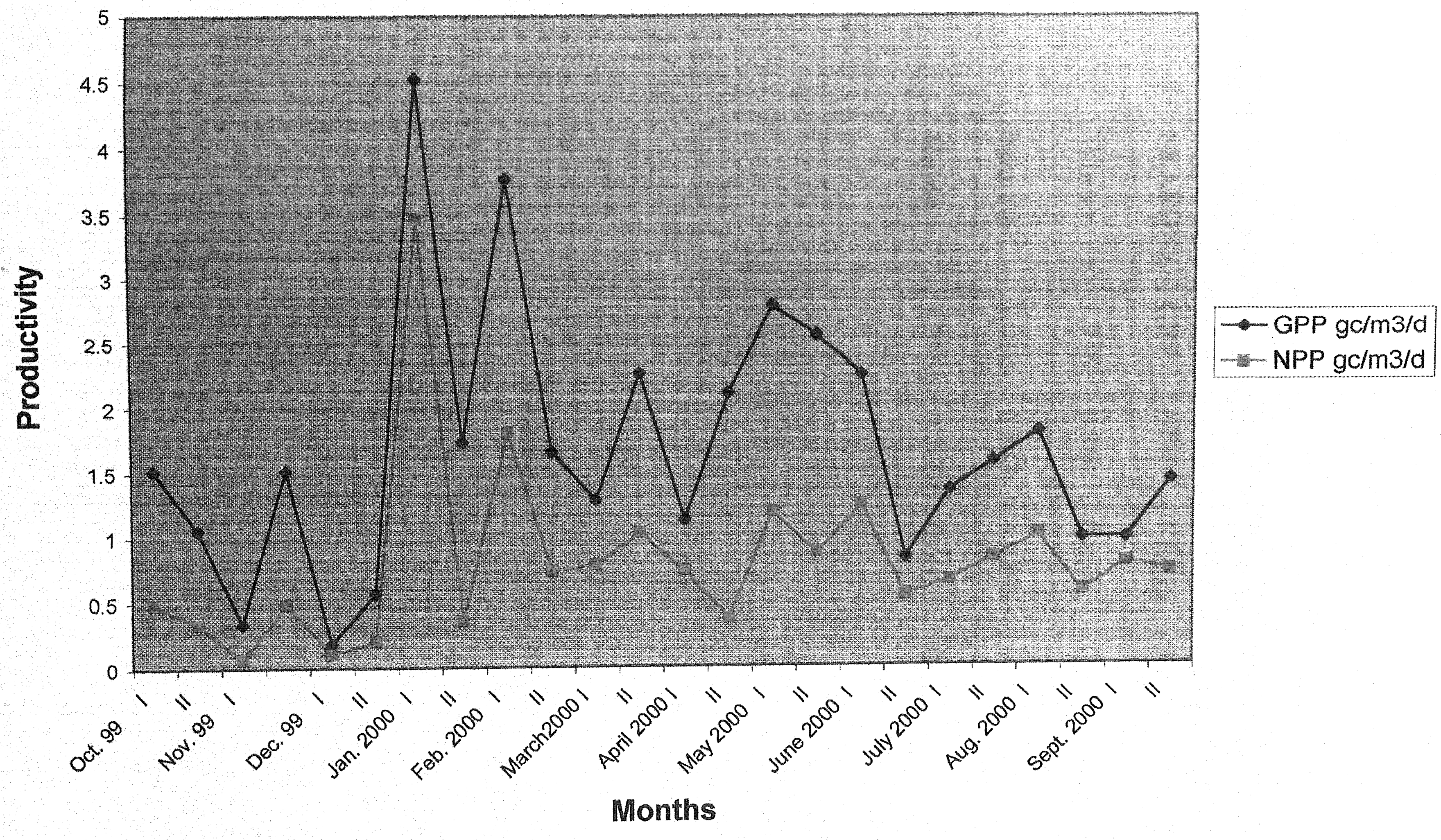
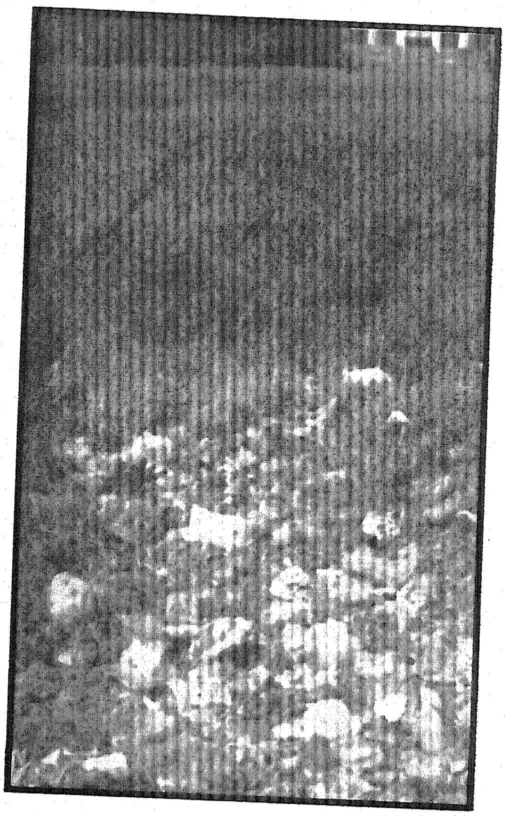


TABLE XVIII B   AVERAGE SEASONAL VARIATION

SEASONS	GPP	NPP	RESP.	NPP:GPP
Winter	1.715	0.860	0.855	0.41
Summer	2.012	0.873	1.139	0.45
Rainy	1.316	0.706	0.609	0.56

PLATE-6



View of dumped Garbage / Polythenes Etc.

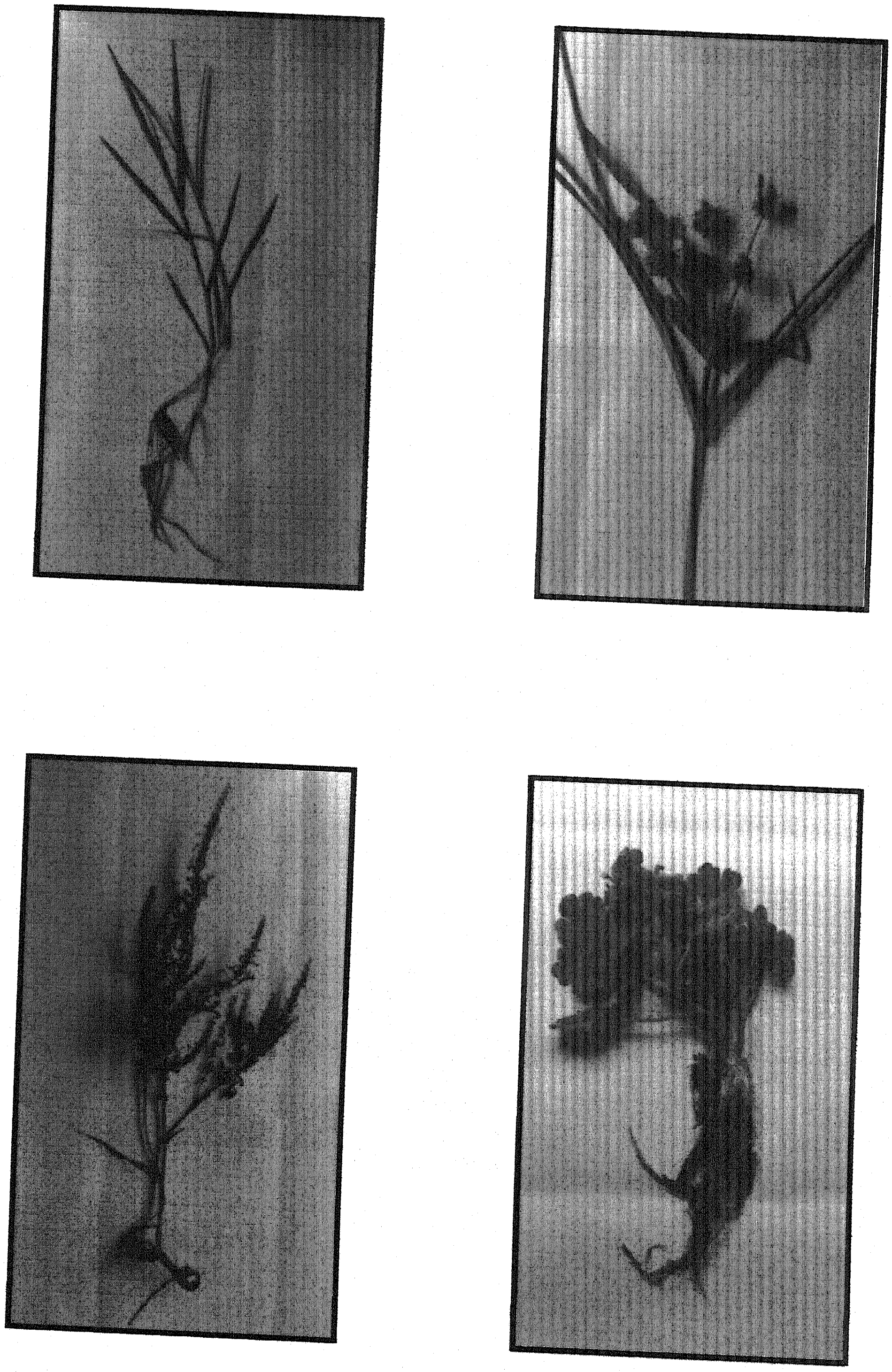
PLATE-7

Angiospermic flora developed.

Land Plants along with aquatic plants.

PLATE-8

Angiospermic flora developed.



Land Plants along with aquatic plants.

SECTION - 6

✦

QUANTITATIVE
AND
QUALITATIVE
ANALYSIS OF MICROBIAL
POPULATION
(Bacterial Study)

SECTION 6

QUANTITATIVE & QUALITATIVE ANALYSIS OF MICROBIAL POPULATION

BACTERIOLOGICAL STUDY

The surface sources of water such as rivers, streams, ponds & lakes are usually polluted with domestic and industrial wastes. Water of many water bodies serve as dumping sites for used water brought in through sewers. Thus water in such cases become a potential carrier of pathogenic microorganisms and can endanger health.

The run off water brings along with it organic substances and soil incorporated with microorganisms which bring about variation in bacterial count. Mild rains result in bacterial contamination of water bodies. Prolonged rain however create opposite effect and serve as diluent of the water body.

Today the conditions of water bodies are rather very tragic as they are highly contaminated and serve as formidable factor for transmission of diseases. Polluted water (with sewage inflow) contains solids and dissolved organic compounds that impart offensive odour & serve as an excellent medium for the growth and multiplication of microorganisms. The microbial population of any reservoir therefore depends upon various factors such as physical conditions of the surrounding area and the status of the surrounding population. The microbial population also depends upon the depth and physical factors such as temperature, light etc.

'Pani Ki Dharamshala' is a typical Reservoir which at present is working as dumping site for the effluents from temples and the surrounding households. During the rainy season the catchment area situated on height causes run off from roads and sewage channels constructed by the sides of the houses along the entire area. The hygenic conditions are such that solid human excreteory products freely flow in the run off water during early rains or during conditions when the rain operates during off time hours. From the adjoining temples, specially the two well recognised and most revered temples of Goddess Annapurna and Lord Shiva, which are Sampling Stations B and C respectively in the present study. All offerings, floral or otherwise are straight-away flown through outlets into the reservoir. Together with these areas there is one Nursing home through which the effluents are also dumped into the reservoir. As such this pond appeared to be a store house of large number of bacterial population, consisting of Coliform as well as other parasitic & saprophytic organisms. Thus the present work for the study of bacterial population was planned under the following lines :-

Bacteriological Analysis involved in the present study was conducted in three parts :-

i) The first part included the **'Plate Count Method'** by which we counted the total number of viable organisms present in water. This is actually a major part of study the organisms depend upon the nutrient present in the medium as some organisms are very specific to their requirement. The results observed are recorded in Table ~~XIX~~ XX Standard Plate Count is the count of Bacterial Colonies produced on Agar medium per ml of sample at 35 ^{0}C and 20 ^{0}C.

ii) Second part included the test for Coliform organisms. Initially **'M.P.N.Count Method'** was applied by which the contamination level of water by Coliforms was detected. The results obtained are recorded in Table XXI

iii) Third part included the detection of presence of certain specific pathogenic bacteria i.e. Salmonella typhii, Streptococcus faecalis and Vibrio choleae.

EXPERIMENT 1. ~ STANDARD PLATE COUNT

The Plate Count is useful in determining the quality of water. It gives an indication of amount and type of organic matter present in the water body. The bacteria that grow at 37 ^{0}C are most likely to be associated with organic matter of human or animal origin, whereas those growing at lower temperature i.e. 20 ^{0}C are mainly saprophytes that normally inhabit the water or are derived from soil and vegetation.

The total viable counts ranged from 17×10^7 to 152×10^7 colonies per ml. The general trend of variation observed at all sampling stations was usually same. In winter months low values were observed, lowest being in December 99. In summers the value increased, highest values were obtained in May / June. Frequent increase and decrease in the viable count was observed in every month in the two fortnights. Results are being given below stationwise.

AT SAMPLING STATION 'A'

The minimum viable count recorded was 18×10^7 in December 99 first fortnight and the maximum viable count was recorded in May 2000 second fortnight, the count being 124×10^7. Since October 99 the number of colonies

gradually decreased till December showing that the bacterial population decreases in winter season while in rainy season the number of organisms decreased.

AT SAMPLING STATION 'B'

The bacterial count obtained at this site was usually more than that at other sites. The seasonal trend of increase and decrease was usually same. Lowest value was recorded in January 2000, i.e. 24×10^7. It increased in summer, highest value being 152×10^7 recorded in June 2000 first fortnight.

From October it started decreasing reaching the least value in January (first fortnight). Thereafter fluctuation in bacterial population was observed.

AT SAMPLING STATION 'C'

The total viable count showed gradual decline from October 99 to December 99 first fortnight showing its least count 17×10^7. Highest count of Bacterial colonies was 100×10^7 in June first fortnight. The number again declined in Rainy season.

EXPERIMENT 2 ~ TEST FOR COLIFORM ORGANISMS

It is important to know the pathogenic organisms present in water to know the condition of the water body. The sewage dumped in the water body serves to be the medium for growth of many bacteria. The important bacterial diseases mainly transmitted by water are typhoid, disentry and cholera.

To indicate the degree of sewage contamination with wastes from human and animal sources, the group of bacteria known as coliforms were detected. Infact Coliform bacilli are reliable indicators of faecal pollution.

The test for their presence is an index of degree of pollution and therefore is carried out on quantitative basis. The Coliform group, Lactose fermenting Gram negative bacilli includes a number of different organisms (Enterobacteriaceae). Those referred to as faecal e.g. *E. Coli* are essentially commensals of intestines, others known as *Klebseilla aerogenes* may grow also in soil and on vegetation and through these sources may get incorporated in water. The typical faecal bacilli eg. E. Coli die in water during the course of several days or weeks after leaving the animal intestine, thus their presence in water is an indication of recent faecal contamination. Coliform group includes all aerobic and facultative anaerobic, gram negative rod shaped bacteria. These ferment lactose within 48 hours at 35 ^{0}C. The method followed for its isolation include – Presumption, Confirmation and Complete Test. Details and the method followed has been explained in Section 2 – Materials & Methods.

EXP 2A. TEST FOR MOST PROBABLE NUMBER OF COLIFORM ORGANISM

The Most Probable Number of total coliform bacteria was done by Multiple Tube Method (APHA 1971). The table used for MPN count of Coliforms per 100 ml water was taken from "Standard Methods for Examination of Water and Waste water 13th Edition APHA 1971".

The results obtained are shown in Table XXI

From the table it can be observed that the MPN count varied from 64 to 2400 organisms per 100 ml of water. Lowest counts at all sites were recorded in December 99, second fortnight, 75 cells/100 ml at site A, 93 cells per 100 ml at site B and 64 cells per 100 ml at site C. Higher counts were usually

observed in summer months. During rainy season the moderate values were obtained. This shows that during high temperature number of coliform increased while during lower temperature their number decreased. The stationwise results obtained are being given below :-

AT SAMPLING STATION 'A'

The MPN count showed decline from October 99 to December 99 (second fortnight) reaching lowest count of 75 cells per 100 ml. In January 2000 and February 2000 the count increased. In March sudden rise in MPN count was observed. In April, May, June and July it remained nearly same. The value being 1100 cells/100 ml of sample. It decreased in August 2000. In September 2000 first fortnight it again rose to 1100/100 ml and then declined.

AT SAMPLING STATION 'B'

The MPN count observed from October to December 1999 followed the same trend as found at sampling station A. The lowest count was observed in December 99 second fortnight i.e, 93 cells per 100 ml. Thereafter it gradually increased to ≥ 2400 cells 100 ml in April 2000 second fortnight. The same MPN count was recorded till July 2000 first fortnight then it fluctuated during alternate sampling reaching 1100 cells/100 ml in September 2000. In March 2000 the value obtained was comparatively low than observed at site A.

AT SAMPLING STATION 'C'

The MPN count decreased gradually from October 99 to December 99 reaching the lowest count of 64 cells/100 ml in second fortnight of December 99. Then a gradual increase in count was observed till March 2000. This value remained same till May 2000 first fortnight, it increased further in May

second fortnight and June first fortnight during which the highest value of ≥ 2400 cells/100 ml was recorded. During the rainy season the value remained at 460 cells/100 ml except in August 1st fortnight when its value recorded was 1100/100 ml.

Coliform count include all non spore forming gram negative aerobic and facultative anaerobic rods that produce acid and gas from lactose. The high counts observed in this reservoir may be due to presence of genera Escherichia and Aerobacter or due to the interaction of two or more species of bacteria by synergism, for this reason confirmed and complete test were performed.

EXP. 2B – CONFIRMED TEST

One ml each from lactose broth tubes showing positive Presumptive test were taken in presterilised petriplate and 15 ml of EMB Agar was added at 40 ^{0}C temperature. After giving rotatory movement, the agar medium was allowed to solidify & then incubated for 24 to 48 hrs. at 37 ^{0}C. The percent occurrence of colonies having dark centre and metallic sheen was noted and tabulated in the Table XXII

RESULT

After observing the plates it was found that two type of colonies appeared

(i) transluscent colonies with dark centres and metallic sheen. (E. Coli)

(ii) Pink mucoid colonies (Aerobacter).

The total colonies of both the types were counted seperately and percent occurrance of E. Coli (transluscent) colonies was calculated and recorded in Table XXII

From the readings recorded in the Table XXI it is evident that the percent occurrance of E. Coli was comparatively high at sampling station B, than their percent occurrence at sampling station A and sampling station C. The population of E. Coli according to their percent occurrance can be said to be more during summer and rainy season than during winter season.

The site wise description for % occurrance of E. Coli during the study period is being given below :-

AT SAMPLING STATION 'A'

The percent occurrence of *E. Coli* at this site showed gradual decrease from Oct. 99 (48%) to December 99, first fortnight (15%). The least occurrence was in December first fortnight and the highest percent occurance was observed to be 71.7% during July 2000, second fortnight.

From December 99 second fortnight it started increasing (from 16%) till July 2000 second fortnight (71.2%).

The percent occurance declined in August 2000, first fortnight to 39.3% and from second fortnight it again increased to 67.3% in second fortnight of September 2000.

AT SAMPLING STATION 'B'

From the beginning of the experimentation i.e. October 99 the trend of occurrance of E. Coli was found to be the same as found at sampling station A, that is from October 99 first fortnight gradual decline was observed till December 99 first fortnight (19.2%).

From second fortnight of December 99 to March 2000 first fortnight the occurrence of *E. Coli* increased i.e. from 19.2% to 68.9%.

The value declined from March second fortnight to April second fortnight and again increased in May 2000 first fortnight, value being 75.7%. In June 2000 first fortnight highest % occurance was recorded i.e. 79.6%. Thereafter till September 2000 it showed declined with occasional rise in July Ist fortnight (75%) and September 2000 second fortnight (68.1%).

AT SAMPLING STATION 'C'

The % occurance of *E. Coli* showed gradual decline from October 99 to December 99 (from 45% to 9%). In January 2000 it increased slightly. Since February 2000 the percentage of presence of *E.Coli* was found to be increasing till June 2000 second fortnight with a drop in the value during May 2000 first fortnight and June 2000 first fortnight. In June Second fortnight the highest percentage of occurance was observed i.e. 67.6%. Thereafter till September 2000 second fortnight the values were comparatively less except in first fortnight of September when it was nearly same.

In general during the winter period the percentage occurance of *E.Coli* declined with fall in temperature and as the temperature increased during summer its percentage increased or it may be due to decrease in the volume of water. With the approach of rainy season the population increased due to surface washings of rain water and as the rainy season progressed the population again declined due to the dilution of water. Even the occasional rise in population was observed due to the surface washing on occasional rains.

EXP. 2C COMPLETE COLIFORM TEST

It is the confirmatory test for the presence of *E.Coli.* It included two parts :

(i) The Lactose Fermentation Broth tubes are again inoculated with isolated Coliform colony from EMB Agar plate using inoculating loop.

(ii) Nutrient Agar slants were streaked with colony from EMB Agar, to perform Gram staining.

Both Lactose fermentation tubes and Nutrient Agar slants were incubated at 37^0C for 24 hours.

RESULT

In Lactose Broth Tubes production of Acid and gas was observed. From nutrient Agar slants colonies were picked up for performing Gram staining. The slides indicated presence of Gram negative rods.

SPECIFIC TEST FOR INFECTIOUS PATHOGENIC BACTERIA

The presence of pathogenic bacteria indicate dangerous impurity of water. Generally these pathogens are so scanty that technical difficulty of their isolation makes the tests impractible. Instead we normally rely on the test that reueal the presence of commensal bacteria of intestinal origin such as those of Coliform group. These do not themselves constitute a hazard, but they indicate that faecal matter has entered the water body. These tests have been done by the author and have already been described in the previous chapter (Material & Methods), side by side some specific tests were performed to find out the preference of specific infectious organisms.

The conditions observed at the reservoir such as dumping of waste matter from house holds, temples and hospitals as well as enterance of drainage systems in to it makes one suspicious of presence of pathogens in the water of this reservoir. Hence to exactly know the condition, the specific tests for checking the presence of Streptococcus faecalis, Salmonella typhii and Vibio Cholerae (The common pathogens) was undertaken.

1. TEST ORGANISM – STREPTOCOCUS FAECALIS

Streptococus is Gram – Ive organism and can resist heat up to 60^0C for 30 minutes S. faecalis is usually present as commensal in intestine and therefore in faeces, hence there is possibility of its occurance in water bodies polluted with sewage.

This organism has the capacity to grow in the medium used for the test of Coliform bacilli and by itself ferments Lactose but without gas production. Hence its presence in the water of the three sampling stations was determined by further examination of the content of the tubes mainly showing acid production only or those with very little amount of gas formation during Presumptive Coliform Test.

S. faecalis was subcultured in tubes of sterile Sodium azide medium. The presence of of S.Faecalis was indicated by uniform turbid growth with acid production in the medium with in 8 hrs. at 45 ^{0}C.

From the above positive tubes their presence was confirmed by plating on Mac conkey Agar after incubation the plates were observed - It was found that along with other colonies, minute (pin point) pink colonies developed on it. These colonies were suspected to be of Streptococus facealis.

For further confirmation Biochemical Tests and Litmus Milk Test were conducted.

BIOCHEMICAL TEST OBSERVATION

After conducting the Biochemical Test the changes observed were recorded in the following **Table**

S.No.	BIOCHEMICAL TEST	RESULT
1.	Mannitol Enriched Media	+
2.	Sucrose Enriched Media	+
3.	Arabinose Enriched Media	-
4.	Sorbitol Enriched Media	+
5.	IMVIC Test	- - + -

Key : + = Positive Test

- = Negative Test

As evident of the table it was found that S. faecalis fermented sugars like Manitoland Sucrose, Sarbitol with gas production. It did not ferment Arabinose enriched medium.

When the inoculum of the suspected organism was subjected to IMVIC Test, It was found that Voges Proskauer test was positive and others were negative which confirmed the presence of S.Faecalis.

LITMUS MILK TEST OBSERVATION

This test was undertaken to confirm the presence of S. faecalis. Litmus Milk Tubes inoculated with suspected colonies of S.faecalis from plating results of three sampling sites, were observed for 'Stormy Clot' formation. Stormy clot was often formed in tubes of sites A and B and rarely in tubes of site C.

After careful observation of Plates, Biochemical Test results and Litmus Milk Test results it could be concluded that frequent occurance of S.faecalis was recorded at site A and B during Summer season and less

occurance during Winter and Rainy Season. However its presence was recorded in all three seasons in water samples of site A and B.

In samples from site C it was rarely found in Summer Season and in Winter and Rainy Season it was not present.

TEST ORAGNISM – SALMONELLA TYPHII

These are non Lactose fermenting Gram negative rods. This bacteria may survive in polluted waters for weeks. Clinically the S.typhii bacteria are said to cause enteric fever in man, Hence their presence in water may prove to be hazardous.

As in the Reservoir under study water from hospitals also enters, possibility of its presence in water can not be denied. Hence the tests for its presence were undertaken.

To isolate S.typhii from the samples of the 3 sampling sites, samples were first inoculated in enrichment medium – Strontium Selenite Borth.

The culture obtained was then plated on :-

(a) Mac Conkey's Bile salt Lactose Agar &

(b) Wilson and Blair's Brilliant green Bismuth Sulphite. Agar (B.S.A.)for specific isolation of S.Typhii.

OBSERVATION OF PLATES

(a) Mac Conkey's Bile salt Lactose Agar Plates

S.typhii's characteristic pale yellow or nearly colours less colonies were rarely observed in plates inoculated with inoculum from sites A and B in Summer Season.

(b) BSA Agar Plates

Two types of colonies appeared on the plates:-

(I) closely packed 1 mm colonies of green or pale brown colour.

(II) Large Colonies having black centres and clear translucent edges characteristic of S.typhii.

BIOCHEMICAL TESTS

After observing the colonies characteristic the suspected colonies were subjected to Biochemical Tests for confirmation. The observation were recorded in the chart

S.No	BIOCHEMICAL TESTS	RESULTS
1.	Glucose enriched media	+
2.	Maltose enriched media	+
3.	Sucrose enriched media	-
4.	Xylose enriched media	+
5.	Arabinose enriched media	-
6.	Mannitol	+
7.	Sorbitol	+
8.	H_2S Production in peptone water	+
9.	I MVIC Test	- + - -

During the Biochemical Tests it was observed that the suspected S.typhii. culture was found to ferment the following sugars with acid production only –

Glucose, Mannitol, Maltose, Xylose and Sorbitol No fermentation was observed in media tubes enriched with Sucrose and Arabinose.

TEST FOR H_2S PRODUCTION

The culture gave positive test as blackening of media was observed. Next time the I MVIC Test results given in the table indicate that the

organism showed positive reaction in Methyl Red Test while negative test were found for Indol, Voges Proskauer and Citrate Test.

From the above observations of the water samples from three sampling stations it was found that S. typhii was occasionally present in water of A and B sampling sites only during Summer and was not found to be present in Rainy and Winter Season. From Water samples of site C it could not the deducted in any of the season.

TEST ORGANISM – VIBRIO CHOLERAE

Vibrio cholerae is a pathogenic Gram negative bacteria which is likely to be prevalent in alkaline medium. This bacteria may die quickly in sewage polluted waters but survive in clean stagnant water for one to two weeks.

The water of the reservoir is stagnant. The sewage enters the reservoir near site B. During the study on Physico-Chemical parameters alkaline nature of water was observed, hence the possibility of its presence can not be ruled out. Thus the tests were carried out to check its presence.

For examination of water samples for Vibrios, enrichment method was employed. The Enrichment Media used was alkaline Peptone Water (pH 8.4) to it 0.1 to 0.2 % Teepol was added to inhibit the growth of spore bearing contaminants.

Separate tubes with the water sample from three sampling stations A, B, C were taken and labelled. These tubes were than incubated at 37 ^{0}C for 6-8 hrs. and then subcultured on plates of Selective media (Monsur's medium) and Mac Conkey Agar Plates.

OBSERVATION OF PLATE CULTURES

(a) Mac Conkey Agar plates

On Mac Conkey's Agar few colonies appeared these were pink (Along with other bacterial colonies). The plates were further incubated as (Other bacterial colonies like those of E.Coli & Streptococcus are also pink). The Plates which were inoculated with Enrichment Medium culture from site A and C indicated towards possibility for presence of V. Cholerae as the pink colonies of these plates on further incubation turned to reddish colour.

(b) **Monsur's Medium**

The colonies observed on the plates of this medium were small, translucent with a grayish black centre. Some colonies showed formation of turbid halo around them. These were suspected as typical V. cholerae colonies.

BIOCHEMICAL TEST

Suspension of a typical colony was inoculated in the biochemical media. The tubes were incubated at 37^0C for 48 hrs. The changes observed were tabulated as under

S.No.	BIOCHEMICAL TEST	RESULTS
1.	Glucose enriched media	A
2.	Sucrose enriched media	A
3.	Maltose enriched media	A
4.	Manitol enriched media	+
5.	IMVIC	+ - - -
6.	Arabinose	-
7.	Lactose	-

Key : A = Acid Production
+ = Positive Reaction
- = Negative Reaction

From the above observation it was found that the test organism suspected to be Vibrio cholerae fermented Glucose, Sucrose, Mannose,

Maltose & Manitol showing acid production without gas evolution. It did not fermented Arabinose and Lactose.

The IMVIC Test results show that the organism gave Cholera red colour indicating towards positive Indole Test. It showed negative Methyl Red Test, Voges Proskauer and Citrate Test were also found to be negative Hence the presence of Vibrio cholerae was confirmed.

From the monthly observation it was found that V. cholerae was rarely present in the Reservoir in Summer season in water sample of site A and C. It could not be detected in Winter and Rainy season. However it was not found in water samples of site B.

Table XIX **SEASONAL OCCURANCE OF SPECIFIC BACTERIA AT DIFFERENT SAMPLING STATIONS OF RESERVOIR**

Bacteria	Sampling Station A			Sampling Station B			Sampling Station C		
	W	S	R	W	S	R	W	S	R
Streptococus faecalis	+	+ +	+	+	+ + +	+	-	+	-
Salmonella typhii	-	+	-	-	+	-	-	-	-
Vibrio Cholerae	-	+	-	-	-	-	-	+	-

Key : W = Winter season
R = Rainy season
S = Summer season
- = absent
+ = Rare
++ = Frequent
+ + + = Abundant

Table XX

MONTHLY VARIATION IN TOTAL VIABLE COUNT PER ML AT DIFFERENT SAMPLING STATIONS

Colonies Counted X Dilution 10^7

Months	Sampling Stage	Samp.St.A	Samp.St.B	Samp.St.C
Oct-99	I	48	104	54
	II	39	100	42
Nov-99	I	36	96	32
	II	28	40	28
Dec-99	I	18	28	17
	II	21	26	38
Jan-00	I	28	24	72
	II	52	32	48
Feb-00	I	32	42	32
	II	28	36	28
Mar-00	I	32	28	24
	II	38	48	32
Apr.00	I	96	100	28
	II	109	120	54
May-00	I	120	144	72
	II	124	112	80
Jun-00	I	48	152	100
	II	60	84	72
Jul-00	I	48	44	60
	II	24	49	48
Aug.00	I	36	52	24
	II	28	76	56
Sep-00	I	36	92	44
	II	40	97	47

Table XXI

MONTHLY VARIATION IN MPN COUNT OF BACTERIA
(Per 100 ml.)

Months	Sampling Stage	Samp.St.A	Samp.St.B	Samp.St.C
Oct-99	I	240	460	460
	II	210	210	240
Nov-99	I	120	150	150
	II	150	150	120
Dec-99	I	93	120	75
	II	75	93	64
Jan-00	I	120	150	75
	II	150	210	120
Feb-00	I	120	240	150
	II	240	460	240
Mar-00	I	1100	460	460
	II	1100	460	460
Apr.00	I	1100	1100	460
	II	1100	2400	460
May-00	I	1100	2400	460
	II	1100	2400	1100
Jun-00	I	1100	2400	2400
	II	1100	2400	460
Jul-00	I	1100	2400	460
	II	1100	460	460
Aug.00	I	460	1100	1100
	II	240	460	460
Sep-00	I	1100	1100	460
	II	460	1100	460

Table XXII
PERCENTAGE OCCURANCE OF E.COLI

Months	Sampling Stage	Samp.St.A	Samp.St.B	Samp.St.C
Oct-99	I	48%	50.4%	45%
	II	35%	36.5%	32%
Nov-99	I	30.2%	32%	29%
	II	28.4%	30.3%	26%
Dec-99	I	15%	19.2%	11%
	II	16%	20.7%	9%
Jan-00	I	19.8%	25%	17%
	II	23.2%	27.7%	14%
Feb-00	I	28%	31%	25%
	II	35%	45%	31%
Mar-00	I	42.8%	68.9%	41.24%
	II	41.3%	67.7%	44.44%
Apr.00	I	44.81%	64.25%	48.12%
	II	46.66%	63.88%	54%
May-00	I	51%	75.7%	53.44%
	II	56.45%	72.3%	58%
Jun-00	I	63.88%	79.6%	45.8%
	II	63.88%	72%	67.6%
Jul-00	I	64.5%	75%	61.36%
	II	71.7%	67.30%	65.6%
Aug.00	I	39.3%	65%	43%
	II	55.4%	65%	52%
Sep-00	I	65.6%	64%	67.7%
	II	67.3%	68.10%	63.4%

SECTION - 7

✦

SUGGESTIVE CONTROL MEASURES

SECTION - 7

SUGGESTIVE CONTROL MEASURES

The major cause of deterioration of water quality of natural water bodies like lakes and rivers and even certain reservoirs like the present under study is the waste disposal mainly in the form of sewage. The waste material usually brings with it lots of organic matter and chemicals. The response of aquatic ecosytems to increased input of nutrients is greater productivity to the detriment of water quality. This inturn leads to Eutrophication, eventually resulting in the extinction of water body.The present reservoir is facing the same situation as continuous inflow of municipial (domestic) waste water; run off water and dumping of solid wastes has totally changed the quality of water ultimately the water surface could not be noticed due to massive growth of macrophytes. The accumulation of organic matter had reduced the capacity of the reservoir. According to the studies of the author this reservoir could be categorised as eutrophic water body.

Abundant nutrients unbalance the normal succession and promote blooms of blue green algae (not easily eaten by zooplankton). Thus the water becomes turbid. Decaying algae settle at the bottom. Due to all these activities not only the water quality changes but also the surrounding air, which gives the fishy odour from decaying matter.

According to Hammer and Hammer 1998 macronutrients for plant growth are carbondioxide, inorganic nitrogen and phosphate, variety of trace elements are also needed for growth.

The key to control rate of Eutrophication is in limiting plant nutrients. Natural waters contain sufficient carbon in the Bicarbonate alkalinity to provide Carbondioxide in excess of growth needs.

In urban areas approximately 30% of phosphorus in domestic waste water is from synthetic detergents. Our high standard of living has resulted in use and disposal of large quantities of phophorus.

The rate of Eutrophication can be retarded by reducing nutrient input. One basic method to limit nutrient concentrations has been diversion of nutrient rich waste water, construction of a pipeline to convey the treated waste water from the city to out skirts. For this a comprehensive metropolitan sewerage plan should be adopted to intercept all waste waters entering the reservoirs and to pipe them to waste water treatment plants.

Advanced treatment can be used to remove nutrients from waste water where diversion is not possible. Emphasis should be on phosphorus removal as it is considered as limiting nutrient and methods are available to precipitate waste water phosphate chemically in wastewater.

Nitrogen compounds are more difficult to eliminate and techniques are costly hence diversion should be considered as a matter of choice.

Although the only effective means of preventing or reversing Eutrophication is nutrient control, several temporary controls have been used in other countries to reduce nuisance effects in enriched lakes and reservoirs, including, artificial mixing, harvesting of plants and algae, chemical control and flushing.

Power driven underwater weed cutters with optional barge loading conveyers are available for harvesting aquatic plants. Although costly weed cutting has been favoured rather than applying herbicides. Removal of algae has been suggested as means for reducing nuisance species and with drawing nutrients. Copper sulphate is commonly used for control of algae in reservoirs, though it has several short comings as a Eutrophication control device. It poisons fishes when used in excessive concentrations. In lakes it must be applied at intervals throughout the growing season to ensure effective algal control; blooms must be anticipated and treated before

they occur. To provide relief from aquatic weeds both pre-emergent and emergent herbicides are available. In case of reservoir with multiple ports at various depths for discharge of water, consideration should be given to releasing that water which contributes most directly to the Eutrophication problem.

Contamination of municipal waste water results from human excreta, food preparation wastes, variety of organic and inorganic industrial wastes. Conventional waste water treatment is a combination of physical and biological processes to remove organic matter. Some reduction in number of viable bacteria and viruses in effluent waste water can be brought about by chlorination.

Protection of public health is the primary concern regarding pathogens in waste waters discharged in water bodies. Conventional biological treatment removes 99 to 99.99% of pathogenic micro organisms in raw waste water. Effluent chlorination can kill 99.99% or more of bacteria and unknown number of viruses and protozoa.

Although a treated waste water may be considered satisfactory for discharge of faecal coliform count is reduced to 200/100 ml, effluent chlorination cannot be considered as disinfection. However resistant pathogens and viruses and bacteria can be harboured and protected from effects of chlorine in suspended organic matter.

Today the avenues for ways of Pollution Control have expanded due to research and innovations. Environmental biotechnology for pollution control uses biological processes to remove pollutants from contaminated water or waste water.A biological process is an engineered system that accumulates desired micro organisms to a sufficiently large mass that the pollutant concentration is lowered to meet some treatment standard during the time that the microorganisms are in contact with the material being treated. Therefore innovations in environmental biotechnology have to be undertaken to find better ways to identify and accumulate desired micro

organisms.

Biological processing is the most efficient way of removing organic matter from municipal waste waters. These living systems rely on mixed microbial cultures to decompose and to remove, colloidal and dissolved organic substances from solution. Most traditional waste water pollutants are either electron donor or acceptors. Thus selection of the desired micro organisms can be achieved by controlling the supply of the other substrat. For example NH_4^+ is an electron donor that is common waste water pollutant. When O_2 is supplied as an electron acceptor, nitribying bacteria grow through aerobic oxidation of NH_4^+ to NO_3^-. Another example of electron donor pollutant is organic matter normally measured as BOD. When O_2 is supplied aerobic heterotrophie bacteria grow through oxidation of C in BOD to CO_2, NO_3^- common pollutant and electron acceptor can be reduced to N_2 gas by denitrification by denitrifying bacteria. For such processes proper selection of micro organisms is done by controlling substrat availablity, their mass in the process must be built up. Infact biological processes include 3 steps -1. Substrat supply (Waste matter in water. (2) Attachment selection and supply of exact micro organisms. 3 Loading the concept is to provide enough contact time between micro organism and pollutants.

After biological treatment of waste water its disinfection is also essential. It requires co-agulation and granular media filteration followed by chlorination with extended contact time. Chlorination kills bacteria and inactivates enteric viruses.

These measures however can be implemented only if government pays attention towards the condition of such neglected water bodies and the government imposes stringent regulations on the waste water treatment. The water should then be allowed to enter the water bodies if cannot be diverted. Similar biological processes should be applied for pollution control of small water bodies with sewage pollution.

SECTION - 8

✦

DISCUSSIONS
&
CONCLUSIONS

SECTION –8

DISCUSSION AND CONCLUSION

Water is the most abundant and essential component of all the living systems. It is an essential element for life. About 70% of the precipitation that reaches the earth's surface directly goes to oceans which constitute 95% of all water present on and hear the earth's surface. Rest follows various routes and this is collected in rivers, lakes, ponds, reservoirs and some seeps and forms underground resource.

The large variations in precipitation pattern result in uneven and irregular distribution of freshwater resources world wide. Apart from the above factors influencing water availability are stability of runoff and size of runoff. In the category of water poor countries India ranks second in the list. (N.N.Sastri 1995).

The ever increasing population and improper practices of waste disposal and over exploitation of resources have deteriorated the quality of natural water resources. not only of surface waters but also of underground water resources.

Jhansi city is situated at latitude of 25^0-27'N and longitude of 78^0-35' E and at an altitude of 271 mts above mean sea level having rocky and undulated topography. Jhansi has a typical monsoonic climate with three distinct seasons. Winter (from mid October to mid February), summer season (from mid February to mid June) and Rainy season (from mid June to mid Oct). The population of this city is about 3.5 lakhs. The city faces acute water scarcity mainly because of low and erratic rainfall, high run off and being

rocky area infilteration capacity is also very low due to which availability of ground water is also low. Due to rapid urbanisation, industrialisation , growth in population the demand for domestic water supply has increased being 69 mld. At Jhansi rivers and reservoirs' water is the sole source of water supply. Due to improper waste disposal and over exploitation the quality of such important resources are deteriorating .

The reservoir selected for study is situated in the heart of the city and is under great stress. During the study period itself it was noticed that there was a rapid increase in the macrophytic coverage and accumulation of organic matter leading to eutrophication. The area of the reservoir extended to 100 x 100 ft with a depth of 10-20 ft. As it is surrounded by densely populated area including schools, hospitals, residential complexes and temples, the reservoir was selected for study to evaluate the quality of water and its effect on the surrounding. The present investigations were carried out between Oct.99 to September 2000. During the study fortnightly samples were collected between 8.30 to 9 am from three Sampling Stations A, B and C from two depths at each site i.e A_1, B_1, C_1 being surface water level and A_2, B_2, C_2 being lower level water from a depth of 5 ft .

The work was carried out to evaluate the effect of seasonal variations on some physicochemical and biological properties colour, temperature, pH, conductivity, Chloride content , Dissolved Oxygen, BOD, free carbondioxide Bicarbonate/carbonate content, Total alkalinity, Calcium content, Magnesium content., Total hardness and phytoplanktons and bacterial dynamism. From the observations made certain conclusions have been derived.

The physico chemical conditions of water are significant factors which determine the quality of water as well as it also affects the planktonic and microbial population. The three seasons have marked impact on the aquatic

environment including physico-chemical and biological parameters seasonal variations also have direct effect on aquatic biology. During summers evaporation rate of water is high which may affect the concentration of certain chemical factors along with temperature. The impact of monsoon bring changes in physico-chemical conditions as well as it may cause depletion of microbial and planktonic community due to dilution, certain organic and inorganic matter enter the water body due to surface runoff in rainy season.

Colour & Turbidity

During the study period it was found that at Sampling Station A the water was clear throughout the study period with few suspended particles and pieces of plant materials while at the other two sites high turbidity was observed occasionally specially in winter months (October 99, November 99, December 99). At Sampling Station C turbidity was observed in January 2000, February and March 2000 which again increased in May and June (summer months).

Turbidity may be due to planktonic population as well as organic and inorganic materials in the water or due to waste disposal. However the water of reservoir often omitted odour which may be due to dissolved organic substances or suspended decaying organic matter or due to activities of microscopic organisms (Belsare etal 1981).

Transparency or colour depends directly on light penetration and scattering, which in turn is dependent upon suspended matter, dissolved organic matter or certain particles, which may be the cause in the present reservoir. Almost similar effect of summer was observed on turbidity by Ajmal and Razi-ud-din 1988 in Kali Nadi.

Temperature

Temperature of water depends upon season time of sampling atmospheric Temperature and surroundings of the Sampling Stations. Temperature effects diurnal variation and brings about changes in biochemical and biological reactions including growth multiplication respiration and decaying. It also affects both bacterial and phytoplanktonic species composition, density and frequency.

The Temperature of the reservoir water showed seasonal variation as well as variation at two levels of water. Water temperature at different Sampling Stations differed depending upon their location and surroundings. Sampling Stations A and B are under the cover of trees and adjacent to the temples and at Sampling Stations C the area was fully exposed to sunlight hence the temperature recorded at A and B was comparatively low than that recorded at Sampling Station C. Temperature was generally low during December, January and February ranging between 16^0 to 23^0 C while during the remaining study period it ranged from 18^0 to 31^0 C. The average seasonal values were usually higher in rainy season at all Sampling Stations and least was observed in winter season.

Higher temperature during the rains may be due to the collection time of samples as the author's collection time was about 9 am i.e the same as that of Adoni & Vaish 1985 whose observations were the same. High temperature of rainy season was also recorded by Bagde and Verma (1985).

Slight Thermal stratification was observed as the temperature of two levels showed difference of 1 to 2^0 C. These observations are in accordance with those of Adoni & Vaish 1985.

During the present study monthly temperature variation could not be specifically correlated as in some months the phytoplanktons showed inverse relationship and sometimes direct relationship with water temperature.

During the study of Diurnal variation it was noticed that there was variation in water temperature throughout the day. Surface water temperature usually increased from 4.30 am to 4.30 pm and in most samples it started showing decline since 8.30 pm to 12.30 midnight.

At 4.30 am the temperature of reservoir water showed uniformity at all three Sampling Stations, surface water temperature being 16^0C and temperature of water at depth being 15^0 C. At 8.30 am tempetature at both the levels had increased.

According to the studies of P.R.Chaudhari ital (1985) it was observed that during dark lower layers loose heat rapidly during night hours surface layers loose more heat up to midnight. At 10 am all layers of water showed even temperature. The results obtained in the present study are related with the above findings to some extent in the present study even temperature was noticed at 8.30 am instead of 10 am as noticed by Chaudhari etal, A.D.Adoni and A.K.Vaishya 1985 in their studies revealed relative decrease in temperature with increasing depth during day hours and during night hours water column remained more or less isothermal. The author found similar trend during the day hours but could not observe isothermal conditions during the night hours.

pH – In the present study the variation range of pH was narrow from 7 to 9. In general the pH of water was towards alkaline side. Highest values were recorded during summer season and lower during monsoon season and lowest average values were recorded during winter season at all Sampling

Stations. Similar trends of variations were observed by other workers like Gupta & Mehrotra 1986, Zutshi and Vass 1978, Hannan and Young 1975.

pH of water could be correlated to some extent with relative quantities of Bicarbonate (Zafar 1966 & Pearsall 1930). It could also be correlated with intensity of pollution (Verma etal 1984, Saksena etal 1966). In the present study pH usually recorded was 8 or above 8 for most of the study period . Verma etal 1984 & Saksena 1966 also reported similar pH value range in their studies.

During the diurnal variation studies, pH did not show greater variation and infact for most of the time ranged between 7.3 to 7.9 with occasional rise to 8 or 8.2 pH. No definite pattern of variation during the different sampling stages of day was observed. However similar condition of negligible variation in pH values was observed by A.D.Adoni and A.K.Vaishya (1985).

According to some workers like L.R.Bhatt etal 1999, negative correlation of pH was observed with Cyanophyceae & Chlorophyceae and positive correlation with Bacillariophyceae. Earlier workers like Jana (1973) and Chari (1980) observed that high pH value was related with heavy bloom of phytoplanktons.In the present study results of average seasonal variation resemble to that of L.R.Bhatt i.e. negative correlation with Chlorophyceae and Cyanophyceae & positive with Bacillariophyceae.

Conductivity

It is the rapid measure of total dissolved solids, higher value of Conductivity also reveals the pollution status as well as trophic levels of aquatic bodies.

In the present study the value of Conductivity was low ranging from 0.4 to 0.8 mMhos. Usually during most of the study period the value recorded was 0.8 mMhos.

The minimum value of Conductivity was observed during December 99 at all Sampling Stations ranging from 0.4 to 0.6 mMho.

Average seasonal value did not show much difference amongst different seasons however lower values were observed in winter season as compared to summer season at Sampling Stations A in upper level water at Sampling Station B in lower level water and at Sampling Station C in both upper and lower level water. These observations to some extent resembled to the observations of certain workers-Trivedy etal 1985, L.R.Bhatt 1999.

No difference could be noticed in average seasonal values of Conductivity in summer and rainy seasons. Water in the present reservoir shows the trend which is quite different from the general trend in which Conductivity of water is higher in the summers as compaired to that of rainy season.

Chloride

Chloride content is usually found to be higher in waste waters. In the reservoir under study the value of Chloride content usually ranged from 3.99 mg/L to 163.45 mg/L . Usually during most of study period the value of Chloride content was observed to be more in upper level water than in lower level water, however reverse trend was observed during four months from January to March 2000 and in August 2000. In the present study after observing the values of Chloride content at different Sampling Stations, it can be said that no fixed trend of Chloride fluctuations could be ascertained. These variations may be due to precipitation evaporation, human activity and waste disposal.

Ajmal etal 1985 found maximum Chloride during winter season and minimum value during summer season in Kali Nadi. In the present investigations similar conditions of maximum value during winter season was observed at Site A upper level (A_1) and Sampling Station C in both upper and lower level water. Contrary to the observations of Ajmal the author in this reservoir found minimum average value during rainy season at A_1 and C_1 Sampling Stations. Many workers during their study have recorded maximum Chloride content during summer season and minimum during winter season. Khan 1981, Palharya and Malviya 1988, Gupta and Menrotra 1991, Singh 1995, Krishnamurthy and Bharti 1997, A.M.K.H Jarousha. Similarly at Sampling Station A in lower level water (A_2) and Sampling Station B in both level (B_1 and B_2) maximum Chloride content was recorded during summer season. At these sampling sites too values in winter season were comparatively low but least values were recorded during rainy season .

High amount of Chloride gives a possible indication of some source of sewage drains opening into the reservoir. The values are however within the acceptable limits as per WHO and Indian water standards

During the diurnal studies also Chloride content varied from one Sampling Station to another and the entire study area did not show any fixed pattern. The values ranged between 56.48 mg/L to 158.45 mg/L.

Dissolved Oxygen

It is an important parameter for water quality assessment. Non polluted water normally has high Dissolved Oxygen, it decreases due to the presence of waste materials.

The factors affecting the oxygen balance in water bodies are input due to atmosphere and photosynthesis of phytoplanktons and aquatic plants,

output due to respiration, decomposition and mineralisation of organic matter and losses to the atmosphere.

In the present study the Dissolved Oxygen value ranged from 3.02 mg/L to 40 mg/L. The highest value was obtained in the begining of the study period. Seasonal variations recorded reveal maximum value during winter season and minimum during summers. This is in accordance with the result of many workers-Hannan 1979, Brajnandan prasad etal 1985, Singh 1995, Udash 1996, Patel and Singh 1998, Singh and Rai 1999 and A.M..KH.Jarousha, L.R.Bhatt 1999.

Decomposition of organic matter is an important factor in consumption of Dissolved Oxygen which becomes more vigorous in warm season. Reduction in oxygen due to respiration and decomposition of organic matter in warmer months was reported by Nasar 1975 and 1978.

In monsoon season slightly higher value of Dissolved Oxygen is recorded, this may be due to reoxygenation of water due to circulation and mixing. There is increase in value during winter months due to circulation by cooling and draw down of Dissolved Oxygen in water (Udash 1996). Similar view and result were presented by Zutshi 1978, Bagde and Verma 1985, Nalin.K.Sastri 1991.

Ganpati 1940 and Nasar & Munshi 1974 stated that temperature is not always the chief controlling factor of oxygen but algal blooms and macrophytes also play an important role.

According to Wetzel 1983 oxygen content is important for direct need of many organisms and affect the solubility and availability of many nutrients and therefore in turn affect the productivity of aquatic ecosystem.

In the present study of the reservoir the Dissolved Oxygen was usually more in surface water than in water at lower level except in April 2000 and

June 2000 first fortnight . Average seasonal values also showed greater amount of Dissolved Oxygen in surface water at all Sampling Stations.

L.R. Bhatt 1999 has clearly correlated Dissolved Oxygen with phytoplanktons & revealed that it had positive correlation with Chlorophyceae and Bacillariophyceae and negative correlation with Cyanophyceae. In the present study monthly value of Dissolved Oxygen and count of planktons did not reveal any fixed trend but according to seasonal variation Dissolved Oxygen showed positive correlation with Chlorophyceae Cyanophyceae and Englenophyceae as highest count of these groups were recorded in winter season and least in summer season, Bacillariophyceae however has maximum count in summer season and least in winter season hence showing negative correlation.

According to the studies of A.D.Adoni 1985 Dissolved Oxygen showed inverse relationship with Carbondioxide and Bicarbonate alkalinity. In the present study of reservoir water this inverse trend was observed in vertical distribution. of Free Carbondioxide and Dissolved Oxygen as mostly oxygen content was found to be more in surface water as compaired to that found in water of lower level and while Free Carbondioxide was usually more in lower level water as compared to surface waters. In monthly variations too during some sampling stages inverse relationship in variation was observed.

In the present study Dissolved Oxygen did not show any specific correlation with Bicarbonate except that in summer season the value of Dissolved Oxygen is lowest but Bicarbonate value was highest in summers.

Many workers like Gonzalves and Joshi 1964, Hannan 1979, Bagde & Verma 1991 have pointed out that highest coliform counts were witnessed in summer when Dissolved Oxygen was least which may be due to heavy consumption of Dissolved Oxygen following dicomposition of Dissolved

Oxygen following decomposition of organic matter by microbes. Similar result of inverse relation between bacterial count of Coliform & Dissolved Oxygen was also noted during the present study.

During the diel variation studied in the present reservoir no fixed trend could be recorded.

Biochemical Oxygen Demand (BOD) is an important index for the assessment of relative oxygen requirement of wastes. It is the amount of oxygen required for biochemical degradation of organic material.

In the present study of reservoir the BOD value ranged from minimum of 3.92 mg/L to maximum value of 29.51 mg/L . Higher values were recorded during summer months and lower values during winter months.

Surface water had usually higher value of BOD than that recorded in lower level water.

The BOD values recorded at Sampling Station C were slightly higher in comparison to A and B Sampling Sites, specially in winter and summer months.

The seasonal variation shows direct correlation with microbial population variations and negative correlations with Dissolved Oxygen content. These seasonal changes had earlier been recorded by various workers of which few are Agarwal etal 1976; Rai 1978, Bagde and Verma 1985 , L.R.Bhatt 1999.

They attributed the highest value of BOD in summer season to the biological activity i.e. due to high organic decomposition during summer the value of BOD is highest . In winters microbial activity is low hence the low value of BOD were recorded.

Free Carbondioxide

In the present study the Free Carbondioxide value of reservoir water ranged between 20 mg/L to 240 mg/L during fortnightly analysis of samples.

In the initial month of study its quantity was found to be more in water at lower depth than in surface water, reverse trend was observed from May 2000 to September 2000 i.e more in surface water as compaired to that in water at depth.

The first peak value was recorded in December 99, thereafter no fixed trend of increase or decrease in free carbondioxide value in reservoir water could be observed.

The records of seasonal variation reveal that higher Free Carbondioxide value was recorded in Rainy season except at B_2 where highest value was recorded in winter and at Sampling Station C_2 where highest value was in summer season.

Usually lowest value of Free Carbondioxide was recorded in summers except at Sampling Station C where least value was recorded in winter season in surface waters (C_1) as well as in lower level water i.e.C_2.

The observations of Free Carbondioxide in the reservoir water under study were in contrast with those found by Mandal and Hakim 1975 and Nalin K Shastri 1991 as they recorded maximum value in summer months.

Michael 1969, Nalin.K.Shastri 1991 stated that Free Carbondioxide content was generally high in polluted waters. Mishra and Saksena 1991 and previous workers Dalela and Verma 1975 also revealed the same.

Kaiser Jamil 1991 in his work has supported the view of McVea and Boyd 1975 that aquatic plants change the quality of water along with other factors, increase in Free Carbondioxide is also observed.

A.M.KH Jarousha observed that Free Carbondioxide content in water is suggested to be due to rain, plant roots and decaying vegetation. His reporting were in accordance with other workers including Singh 1960, Minhawar 1970, Rao 1972 that Free Carbondioxide value is highest in summer and lowest in winter. In the present study this condition was observed only at sampling staion C. This high Free Carobondioxide content has been explained by Welch 1952 that higher decomposition of organic matter lead to release of more carbondioxide and thus its value remained higher.

In the reservoir under study during diurnal variations it was noted that alteration in Free Carbondioxide value did not show any fixed trend. Since 4.30 am to 12.30 noon values declined and then from 4.30 pm 12.30 midnight the values increased reaching the peak at 12.30 midnight at all Sampling Stations. Variation at two surface did not show a fixed trend till 12.30 noon. Sometimes it was more in surface water, sometimes in lower level water that too at different Sampling Stages at different Sampling Stations. From 4.30 to 12.30 midnight a fixed pattern was however recorded with context to the two levels, it was usually found to be more in lower level water at all Sampling Stations.

P.R.Chaudhari etal 1985 found similar result with reference to the concentration of CO_2 which was more in water during night hours, this he explained was due to absence of photosynthetic activity of phytoplanktons and plants.

Bicarbonate

In the present study of Reservoir, a zigzag pattern of fluctuation in Bicarbonate content was observed as from the beginning of the study (October 99) to December 99 increase in its value was observed thereafter it declined and suddenly its value increased in April 2000. Maximum value of

Bicarbonate content was observed in April and May 2000 from May to end of July 2000 again decline in value was observed. The values usually ranged between 170.8 mg/L to 732 mg/L, usually more in lower level water except at few sampling stages when it was more in surface water.

Seasonal variation of Bicarbonate in the reservoir show that higher values were recorded in summer season and minimum value in Rainy season.

The seasonal variations are in conformity with Rao 1972, Munnawar 1970, Braj Nandan Prasad etal 1985, S.Kaushik and D.N.Saxena 1991 reported from Suraj Kund water highest value in summers but lowest value in winter season. According to Someshekhar 1984 higher values of Bicarbonate occurred during summer and suggested it on account of mixing of effluents. On the contrary D.N.Saxena, M.N.Saxena and S.Kaushik 1991 in winter and least in Rainy season; S.K.Chaurasia and A.D.Adoni 1985 reported maximum Bicarbonate alkalinity in rainy season and minimum in summer season.

Kaiser Jamil 1991 based his evaluation on Mc Vea and Boyd's 1975 reports and started that Macrophytes usually lower the value of Bicarbonates.

Pearsall 1930 and Zafar 1964 , K.Wajahat Shah 1992 revealed direct relationship of Bicarbonates with Calcium content and that both Bicarbonates and Calcium showed inverse relation with pH . However the author in this reservoir found a direct correlation between the Bicarbonates and Calcium with pH.

In diurnal variations' observations the content ranged between 170.44 mg/L to 236.32 mg/L. From 4.30 am to 8.30 pm it was usually more in lower level water as compared to upper level water and at 12.30 midnight reverse was observed i.e Bicarbonate content in upper level water was higher as compaired to that found in lower level water, the Bicarbonate content at this Sampling Stage was highest at all Sampling Stations.

From the overall datas it could be said that there was general increase in the Bicarbonate content from 4.30 am to 12.30 noon; then fall in readings till 4.30 pm after which there was a gradual rise in value reaching its maximum at 12.30 midnight.

Our observations are similar to those of A.D.Adoni and A.K.Vaishya 1985. They also found more Bicarbonate alkalinity in summer season and least in rainy season Usually more in lower level water. In their studies also there was decrease in Bicarbonate content from 9 am to 3 pm and thereafter increase till 12.00 midnight.

Total Alkalinity – The Total Alkalinity of the present reservoir is based on Bicarbonate Alkalinity as carbonate and hydroxide Alkalinity was absent. The variations in Total Alkalinity were similar to that of Bicarbonate content .The Total Alkalinity was high in December 99 showing first peak, thereafter since January 2000 decline was observed till March then its values suddenly reached to maximum in April 2000. Value ranged between 192 to 600 mg/L.

The seasonal variations observed for Total Alkalinity were also similar to that of Bicarbonate content as Total Alkalinity was also maximum during summer season and least in Rainy season. This result is similar to that of L.R.Bhatt etal 1999, he explained the maxima in summer is due to the result of evaporation of water.

Brajnandan Prasad etal 1985 however reported higher values during winters and late summers.

Philipose 1960 had found higher value of Total Alkalinity in polluted waters.

According to Kaiser Jamil 1991 Alkalinity of water is significant in many uses and treatments of natural and waste waters.

A different result had been observed by A.M.KH. Jarousha as he had recorded maximum value during monsoon season and minimum duing winter season.

L.R.Bhatt etal 1999 had correlated Total Alkalinity with phytoplanktons. He found positive correlation with Cyanophyceae & Chlorophyceae and negative correlation with Bacillariophyceae. The reverse condition was found by the author in the reservoir under study.

The diurnal variations in Total Alkalinity followed the same trend as that observed in Bicarbonate content showing positive correlation with it.

From 4.30 am to 12.30 noon it was more in lower level water at all sites. At 4.30 reversal was observed at B and C Sampling Stations. At 8.30 pm again it was more in lower level. At 12.30 midnight again it was more in surface water, hence no fixed trend of variation was recorded in water samples of the two depths.

Calcium Content

In The present study the calcium content in reservoir water fluctuated to a great extent. No fixed trend of variation was observed.

The Calcium content in water samples from the two levels showed varied trends, at different Sampling Stations. Vertical distribution also did not follow any fixed pattern. For some period it was more in surface water and in some other period it was found to be more in lower level water.

The value of Calcium content usually ranged between 21.03 mg/L to 153.07 mg/L. Peak values at different Sampling Stations were recorded in different months. The seasonal variation however showed highest value during winter season at all Sampling Stations at both levels, except at Sampling Station C in surface water (C_1) where highest values were recorded during summer season. At Sampling Station 'A' lowest value of Calcium

content was found in summer season. At Sampling Station 'B' least value of surface water was in Rainy season and in lower level water it was in summer season. At Sampling Station 'C' the lowest value was recorded during Rainy season. Munawar 1970 also noted higher values of Calcium during winters and in summers. Brijnandan Prasad etal 1985 also reported that periodicity of calcium did not show any fixed pattern.

A.M.KH. Jarousha's observation however were contradictory to the above findings as he recorded higher value of Calcium content in Monsoon season and lowest in summers.

According to Kaiser Jamil Calcium contributes to Total Hardness of water and it increased in water containing hyacinth plants. During the diurnal variation studies the Calcium content showed direct correlation with the Bicarbonate content. Minimum amount of Calcium content in the reservoir was recorded at 12.30 noon while its maximum values were obtained at different sampling stages in water sample from different Sampling Stations.

No fixed trend was observed in its variation, however the values usually decreased till 12.30 noon at all Sampling Stations, thereafter a zigzag pattern was observed.

Total Hardness

Total hardness is the sum of Calcium and Magnesium concentration.

In the present study of the reservoir, it ranged from 102 mg/L to 414 mg/L . It was observed that the water at surface level was generally more hard for maximum part of the study period except in some winter months at different Sampling Stations specially between October 99 to January 2000.

Average seasonal values varied from one Sampling Station to another, usually higher values were recorded in winter season at Sampling Station A_2 (lower level), B_1, B_2 (upper and lower level) and C_2 (lower level).

At A_1 (upper level) highest value was recorded in Rainy season and at C_1 in summer season. Similarly lowest average seasonal value was recorded to be in different seasons at different Sampling Stations. The trend differs from those observed by other workers.

L.R.Bhatt etal 1999 recorded maximum values during summer season and lowest during winter season. He explained the highest value in summer season was due to excessive evaporation.

A.M.KH Jarousha 1999 reported maximum value of Total Hardness in monsoon season and minimum in summer season. Twort etal 1974 classified water having hardness up to 75 mg/L as soft, 76 to 150 mg/L as moderate, 151 to 300 mg/L as hard and more than 300 mg/L as very hard. Accordingly the present reservoir water showed variation from moderate hardness to hard. similar results were recorded by Krishnamurthi and Bharati 1995, Pujari & Sinha 1999.

Brajnandan Prasad etal 1985 observed that hardness values are higher in ponds which are more polluted thus we can say that **Pani Ki Dharamshala** Reservoir also falls under the same category.

During the diurnal studies the Total Hardness was always higher as compaired to the Calcium Content. The trend of variation was similar to the Calcium Content i.e generally a higher value was recorded in water at depth as compaired to that of the surface water.

Magnesium

The Magnesium content of the reservoir water evaluated during the present study ranged from 2.56 mg/L to 68.14 mg/L. No fixed pattern of increase or decrease in the value of Magnesium content could be observed.

From the studies on vertical variation at the two depths also no trend could be ascertained.

Considering the seasonal average values it could be noticed that the Magnesium content in the reservoir was highest during winter season and least during rainy season.

Brajnandan Prasad etal 1985 during their studies on some ponds of Lucknow found two peak values, one during winter season and other during summer season. Observing the higher value of Magnesium (between 8.59 to 90.75 mg/L) he suggested affinity between Magnesium concentration and organic pollution.

Zafar (1964,66), Munawar (1970) and Rao (1971) have also found a dirdt corretation between Magnesium content and organic matter of the water bodies.

The Magnesium content in the present study was always lower than Calcium in water of all Sampling Stations. This resembled the findings of Dakshini and Soni (1979), Reddy (1984), Nirmala Kumari (1994) and A.M.KH.Jarousha (2000).

Phytoplankton Study

The pond under study is a perennial water body with inlets for municipal sewage and household refuge. In the present study the monthly recorded Phytoplanktonic population depicts higher counts during the initial period of studies which gradually decreased due to the overload of macrophytes. The highest count was recorded in October 99 with a population of $60*10^3$ cells/L. In all 18 planktonic algae have been identified from the composite samples collected at various months from this reservoir.

Chlorophyceae was the most abundant group in this pond as far as the number of species were concerned. However Cyanophyceae was numerically abundant.

Bacillariophyceae were third. Prescott 1939, Patil etal 1983, Desai 1987 have however found dominance of Cyanophyceae and Bacillariophyceae over Chlorophyceae but in the present study the author found Chlorophyceae as the most successful group as it was represented by 8 genera; Cyanophyceae by 6 genera; Bacillariophyceae by 3 and Euglenophyceae and by 1 genera. (members of Chlorophyceae; Cyanophyceae and Bacillariophyceae were present in water samples throughout the study period while Euglenophyceae were generally present during the winter months when water temperature was low, water was clean with sufficient amount of Dissolved Oxygen. Water quality improved due to self purification).

The water was alkaline in nature throughout the study period. Temperature appears to play a primary role in the species variation of Phytoplanktonic population. Highest population was recorded during the winter months moderate during Rainy season and minimum during Summer months as will be observed from Table XV A and XV B. Luxuriant growth of Phytoplanktons during the post monsoon season coincides with low temperature, pouring in rains, relative humidity, moderate concentration of nutrients and higher Dissolved Oxygen.

The following genera was recorded:- <u>In Chlorophyceae</u> Ankistrodesmus falcatus, Chlamydomonas angulosa, Chlorella vulgaris, Cosmarium granatum, Scenedesmus, Spirogyra sps, Pediastrum simplex & Closteruim.

<u>In Cyanophyceae</u> – Aphanocapsa, Chroococcus sps, Merismopedia, Oscillatoria, Phormedium sps and Microcystis aeruginosa.

<u>In Euglenophyceae</u> – Englena sps.

<u>In Bacillariophyceae</u>- 3 genera- Pinnularia viridis, Navicula radiosa and Synedra affinis.

This suggest that it is a typical Eutrophic lake with increasing organic matter and may sometimes lead to Oligotrophism. Present study also reveal that Chlorophyceae and Cyanophyceae have a negative correlation with the temperature. Jana 1973 and Chari 1980 also observed that temperature is a critical factor for the seasonal periodicity of phytoplankton.

The author found negative correlation of Alkalinity with Cyanophyceae and Chlorophyceae whereas positive correlation with Bacillariophyceae

Oxygen content of water is important as it is the direct need of microorganisms and at the same time solubility of many nutrients also depend upon it. During the present study lowest average value of 6.1 mg/L was obtained during the summer which increased during the rainy season and attained the highest value during winters. The factors affecting oxygen balance are input from the atmosphere, photosynthesis, output of respiration, decomposition and mineralisation of organic matter. Low content of Dissolved Oxygen is a sign of organic pollution. In the present study Dissolved Oxygen was lowest during the summer season which may be due to vigorous decomposition of organic matter during warm weather. During monsoon re-oxygenation takes place due to circulation and mixing by inflow from monsoon rains which in winter increased due to circulation of water by cooling and draw down of Dissolved Oxygen in water. Similar result has been obtained by Udash 1996 and Thapa 1994. The correlation of Dissolved Oxygen was found positive with Chlorophyceae & Cyanophyceae and negative with Bacillariophyceae.

Total Planktonic population was maximum in winters and minimum in rainy season. During winters Cyanophyceae occupied 46.79 % of the total population, Chlorophyceae occupied 30.13% and Bacillariophyceae and Euglenophyceae occupied 14.74% and 8.33%. During summer season

Phytoplankton was dominated by Cyanophyceae which occupied 48.95%, followed by Bacillario-phyceae occupied 28.88%, Chlorophyceae occupied 24.44 % and Euglenophyceae was nearly negative 0.74%. During Rainy season also Cyanophyceae dominated occupying 45.83% followed by Chlorophyceae which occupied 29.17%, Bacillariophyceae occupied 23.33% and Euglenophyceae occupied 1.67%.

Kaushik etal 1991 suggested that species of Scendesmus, Navicula, Oscillatoria along with some members of Volvocales and Chlorococcales remain dominant in a tank regularly receiving sewage.

Franklin 1972 suggested that blue green algae are general indicators of Eutrophy of water.

Ramarao etal 1978 have also designated green algae to be the indicators of highly polluted waters.

Prasad and Singh 1980 are of the opinion that sewage contamination favours the growth of Chlorophyceae, as such this reservoir can be considered to be sewage polluted Eutrophic Reservoir.

Primary Productivity

Primary Productivity of a water body is the manifestation of its biological production and is an ultimate outcome of photosynthesis.

According to Wetzel 1966 (a), Primary Productivity of aquatic environments basically depends on the photosynthetic activity of the autotrophic organisms and has been used as potential index of productivity for many diverse ecosystems.

Nannoplanktons and Ultraplanktons generally assimilate much more carbon per unit biomass than net planktons like large diatoms or blue green algae (Findenegg 1965, Qasim etal 1974, Khan and Zutshi 1979).

In the present study the monthly variations in GPP and NPP did not show regular pattern of rise or fall in value. The fluctuations were very frequent even within alternate fortnights of a month. The value of GPP ranged between 0.188 $gC/m^3/d$ (December 99 first fortnight) to the highest value 4.534 $gC/m^3/d$ (January 2000 first fortnight). The fluctuations in NPP followed the similar trend and the values ranged between 0.075 $gC/m^3/d$ (November 99 first fortnight) to 3.476 $gC/m^3/d$ (January 2000 first fortnight).

The pattern of seasonal variation was generally in accordance with other workers as highest average value was recorded in summer season followed by winter season and least value was recorded in rainy season. This is in accordance to the trend reported by S.R.Mishra and D.N.Saksena 1992 in their study of primary production of sewage collecting Morar River, Gwalior.

H.M.Saran and A.D.Adoni 1985 during their studies on Primary Productivity in Sagar Lake found maximum value in summer but minimum value was recorded by them in winter season.

Prasad and Nair 1963; Sreenivasan 1964 a, b, 1969; William and Murdoch 1966; Khan and Siddiqui 1971; Adoni 1975; Purush- ottaman and Bhatnagar 1976-explained that the increase in Primary Productivity during summers is due to bright sunshine high temperature, low transparency, high phytoplankton density and blooms. Declining tendency during rainy season is due to reduction in size of Productive zone, increase in water level, low temperature, light intensities, dilution in nutrients and cloudy weather, low temperature and light intensity might be the reasons limiting the rate of productivity during winter season.

In the present study it was found that the value of GPP and NPP was quite low, this might be due to mixing of sewage. Shukla etal 1989 have also found that Primary Productivity is adversely affected by sewage and

industrial effluents. Patra 1985 had also reported that the rates of GPP and NPP are adversely affected due to human and animal abuse of water, industrial effluents and sewage disposal. Kar etal 1987 has also attributed low NPP: GPP ratio to pollution load.

Jhingran and Pathak 1988 have shown that the productivity potential of river Ganga was minimum at polluted site (at Kanpur) and it increased to maximum at Allahabad where water quality improved greatly.

The relationship between Net and Gross Primary Productivity as will be evident from Table XVIII is not constant, it changes from time to time as it depends on the environmental conditions, age and structure of community. A high ratio indicates high NPP and low respiration

Bacterial Study

The reservoir under study i.e **"Pani ki Dharamshala"** is eventually serving as the dumping site of effluents from temples, household sewage and even hospital. Not only do sewer lines enter the reservoir but even solid waste matter is thrown in it. As such it is expected to bear a large numbers of bacterial population. Thus in the present study analysis for bacterial population was carried out under the following lines.-

A- Standard Plate Count

B- Test for sewage pollution (including Coliform test-M.PN count)

C- Detection of certain specific pathogenic bacteria- Salmonella typhii, Streptococcus faecalis and Vibrio cholerae.

Standard Plate Count

Result shown in table XIX reveal that the Total viable counts in the reservoir ranged from 17×10^7 to 152×10^7 colonies per ml. General trend of variation observed was usually same at all Sampling Stations. Low values were observed in winter months, lowest being in December 99. In summers

the value increased, peak values were usually recorded in May or June 2000. Frequent rise and fall in the viable count was usually noted at every alternate samplings.

At Sampling Station A minimum count recorded was 18 x 10^7 (December 99 first fortnight) and the maximum count recorded was 124 x 10^7 (May 2000 second fortnight). From October to December 99 there was decrease in number of colonies showing low bacterial population in winter seasons. The highest total count was recorded during summer season, in rainy season the count was lower than that recorded in summer but higher than winter season.

At Sampling Station B the count was found to be highest amongst all Sampling Stations. The total viable count ranged between 24 x 10^7 (January 2000) and 152 x 10^7 (June 2000 first fortnight).

At Sampling Stations C it ranged between 17 x 10^7 (December 99 first fortnight) to 100 x 10^7 (June 2000 first fortnight). From observation it can be noted that the bacterial population was higher at Sampling Station B (Near Annapurna Temple).

In order to study the level of sewage pollution Coliform group of bacteria were considered as index for the degree of pollution. MPN count of Coliforms were carried by the present worker. For Presumption Test, Lactose broth was used and for Confirm. Test EMB Agar medium was used and then Complete Tests were performed.

From Table XX it was observed that the MPN count in the reservoir water ranged between 64 to 2400 organisms per 100ml of water. Lowest counts at all sites were recorded in December 99, 75cells/100ml at A, 93cells/100ml at B and 64 cells/100ml at C. Higher counts were usually recorded in summer season, highest count being 1100 cells/100 ml at A;

2400 cells per 100 ml at B and C in June 2000. During rainy season moderate MPN counts were recorded at all Sampling Stations.

From the average seasonal values of MPN count it was observed that in all seasons usually highest counts were recorded at all Sampling Stations.

From the readings recorded in Table XXI it is evident that percent occurance of E.coli was comparatively high at Sampling Station B. According to percent occurance the population of E.coli. can be said to be more during summer and rainy season and and least during winter season. The percent occurance of E.coli at all Sampling Stations showed the same trend of decline from October 99 to December 99. At Sampling Station A it varied between 15% (December 99 first fortnight) to 71.7% (July second fortnight); at Sampling Station B it varied between 19.2% (December 99 first fortnight) to 79.6% (June 2000 first fortnight) and at Sampling Station C 9% (December 99 second fortnight) to 67.7% (September 2000 first fortnight). Thus it can be concluded that highest percent occurance of E.coli was recorded at Sampling Station B.

According to the result quoted by U.S.Bagde and A.K.Varma 1991 the trend of seasonal variation was similar i.e decline in MPN count during winter season and peak attained during summer season. Bacterial population was low in rainy season and lowest in winter season. According to them there existed direct correlation between Coliform bacteria and pH and electrical conductivity. Similar correlation was observed in the present study with pH.

According to Bagde and Varma high temperature favoured the growth while lower temperature retarded the growth and multiplication of bacteria as is also evident from the present study. They also showed negative correlation with Dissolved Oxygen as in winters Dissolved Oxygen was found to be highest and the least bacterial population was recorded in winter season. The

present study observations are in accordance with their findings. The pH of the reservoir ranged between 7.1 to 9.3 which was found to be quite suitable for the bacterial population.

Thimman 1964 also found that most organisms grow only within pH range 4 to 9.

The decomposition of organic matter is an important factor in consumption of Dissolved Oxygen. The highest Coliform counts were recorded in summer when Dissolved Oxygen was least. According to Gonzalves and Joshi 1964; Hannan 1979 this may be due to consumption of Dissolved Oxygen in warm weather following decomposition of organic matter by microbes.

According to Hannan BOD seemed to be appropriate index for assessing pollution load of some water bodies. In the present study BOD could be positively correlated with Coliform counts (infact generally with bacterial count) as higher BOD value corresponded with higher count (specially seasonal variation). The studies of Agrawal etal 1976 a, b also revealed the same trend.

Water samples obtained from all the three Sampling Stations were tested for the presence of infectious pathogenic organisms– Streptococcus faecalis, Salmonella typhii and Vibrio cholerae.

Streptococcus faecalis was found to be a gram positive organism which fermented Lactose without gas production. It grew well in Sodium Azide medium and indicated uniform Turbidity with acid production. On Mac.Conkey Agar it developed characteristic pink colonies. Biochemical tests reveal that the organism was able to ferment Mannitol, Sucrose and Sorbitol with gas production but not Arabinose. It gave positive Voges Proskauer test and was negative towards Indole Methylene Blue and Citrate test. At

Sampling Station A it could be detected in all the 3 seasons and frequently found during summer season. At Sampling Station B it was abundant during summer season and rarely found in winter and rainy season. At Sampling Station C it was present during summers and could not be detected during winter and rainy seasons.

Salmonella typhii is a non Lactose fermenting bacteria. The possibility of its presence in the reservoir water could not be ruled out as the sewage water from hospital enters into it. It grew well on BSA Agar forming large colonies having black centres and clear translucent edges. On Mac Conkey's Agar plate few pale yellow, nearly colourless colonies were observed on plates inoculated with water sample from Sampling Station A and B in summer season. It fermented Glucose, Mannitol, Maltose, Xylose and Sorbitol with acid production only. It gave positive H_2S production test in Peptone Water. It showed positive M.R test while negative Indole, VP and Citrate tests. It could be occasionally detected in water of Sampling Stations A and B only during summer season and not in winter or rainy season.

Vibrio cholerae is pathogenic gram negative bacteria. The water of reservoir is alkaline and sewage entered the reservoir near site B. Mac Conkey Agar plates inoculated with Enrichment Medium Culture from A and C indicated towards presence of V.cholerae. On Monsur's medium small translucent colonies with greyish black centre developed, these were suspected to be typical V.cholerae colonies. The organism fermented Glucose, Sucrose, Mannose, Mannitol and Maltose, showing acid production without gas evolution.

It showed positive Indole test and negative MR,V.P and Citrate tests. V.Cholerae was rarely found in water samples of A and C in summer season.

TABLE -XXIII
STATISTICAL ANALYSIS OF WATER TEMPERATURE

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	20.38	2.78	0.99	0.14
A2	19.25	2.90	1.03	0.15
B1	21.25	2.63	0.93	0.12
B2	20.38	2.45	0.87	0.12
C1	20.88	3.69	1.31	0.18
C2	19.00	3.35	1.19	0.18
SUMMER A1	23.25	2.44	0.86	0.10
A2	21.13	2.15	0.76	0.10
B1	24.88	2.98	1.06	0.12
B2	22.50	3.24	1.15	0.14
C1	22.88	2.52	0.89	0.11
C2	20.63	2.18	0.77	0.11
RAINY A1	26.88	1.62	0.57	0.06
A2	25.13	1.45	0.52	0.06
B1	27.38	1.80	0.64	0.07
B2	25.88	1.54	0.54	0.06
C1	26.13	2.37	0.84	0.09
C2	25.75	2.86	1.01	0.11

TABLE -XXIV
STATISTICAL ANALYSIS OF pH

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	7.46	0.09	0.03	0.01
A2	7.23	0.10	0.03	0.01
B1	7.69	0.27	0.09	0.03
B2	7.76	0.42	0.15	0.05
C1	7.54	0.27	0.10	0.04
C2	7.39	0.23	0.08	0.03
SUMMER A1	8.68	0.55	0.19	0.06
A2	8.56	0.63	0.22	0.07
B1	8.56	0.65	0.23	0.08
B2	8.31	0.68	0.24	0.08
C1	8.41	0.61	0.22	0.07
C2	8.20	0.54	0.19	0.07
RAINY A1	10.74	6.53	2.32	0.61
A2	10.64	5.81	2.06	0.55
B1	10.78	6.52	2.31	0.61
B2	10.48	5.50	1.95	0.53
C1	11.40	7.41	2.63	0.65
C2	11.21	6.96	2.47	0.62

TABLE -XXV
STATISTICAL ANALYSIS OF CONDUCTIVITY

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	0.74	0.09	0.03	0.12
A2	0.73	0.08	0.03	0.11
B1	0.70	0.07	0.03	0.10
B2	0.64	0.14	0.05	0.22
C1	0.69	0.12	0.04	0.17
C2	0.65	0.15	0.05	0.23
SUMMER A1	0.80	0.00	0.00	0.00
A2	0.75	0.05	0.02	0.07
B1	0.78	0.04	0.02	0.06
B2	0.78	0.04	0.02	0.06
C1	0.75	0.07	0.03	0.09
C2	0.71	0.03	0.01	0.05
RAINY A1	4.18	9.01	3.19	2.16
A2	3.91	8.35	2.96	2.13
B1	4.14	9.02	3.20	2.18
B2	3.78	8.02	2.84	2.13
C1	4.51	10.01	3.55	2.22
C2	4.38	9.69	3.43	2.21

TABLE -XXVI
STATISTICAL ANALYSIS OF CHLORIDE CONTENT

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	79.04	33.91	12.02	0.43
A2	73.16	29.32	10.40	0.40
B1	74.16	24.61	8.73	0.33
B2	67.85	24.33	8.63	0.36
C1	77.72	33.92	12.03	0.44
C2	71.29	27.35	9.70	0.38
SUMMER A1	73.54	28.49	10.10	0.39
A2	75.10	8.39	2.98	0.11
B1	93.78	15.71	5.57	0.17
B2	85.67	13.46	4.77	0.16
C1	76.23	6.65	2.36	0.09
C2	65.54	7.53	2.67	0.11
RAINY A1	68.48	31.63	11.22	0.46
A2	71.48	27.04	9.59	0.38
B1	64.92	37.06	13.14	0.57
B2	65.67	34.00	12.06	0.52
C1	69.35	39.06	13.85	0.56
C2	73.23	#REF!	#REF!	#REF!

TABLE -XXVII
STATISTICAL ANALYSIS OF DISSOLVED OXYGEN

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	14.25	3.84	1.36	0.27
A2	9.64	2.21	0.78	0.23
B1	14.97	10.11	3.58	0.68
B2	11.92	9.52	3.38	0.80
C1	13.81	9.30	3.30	0.67
C2	11.04	8.55	3.03	0.77
SUMMER A1	10.66	3.78	1.34	0.35
A2	8.80	2.00	0.71	0.23
B1	6.75	2.54	0.90	0.38
B2	6.10	1.27	0.45	0.21
C1	7.13	1.70	0.60	0.24
C2	6.93	0.99	0.35	0.14
RAINY A1	12.54	5.92	2.10	0.47
A2	10.00	6.27	2.22	0.63
B1	12.09	6.15	2.18	0.51
B2	10.87	5.64	2.00	0.52
C1	13.30	6.90	2.45	0.52
C2	11.66	7.01	2.49	0.60

TABLE -XXVIII
STATISTICAL ANALYSIS OF BIOCHEMICAL OXYGEN DEMAND

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	5.69	1.56	0.55	0.27
A2	5.62	1.74	0.62	0.31
B1	5.90	2.08	0.74	0.35
B2	5.32	1.38	0.49	0.26
C1	7.17	1.47	0.52	0.20
C2	6.74	1.32	0.47	0.20
SUMMER A1	16.50	3.89	1.38	0.24
A2	15.19	4.08	1.45	0.27
B1	13.91	3.49	1.24	0.25
B2	12.85	3.37	1.19	0.26
C1	18.20	6.56	2.33	0.36
C2	15.91	6.76	2.40	0.42
RAINY A1	12.32	6.20	2.20	0.50
A2	11.67	5.71	2.02	0.49
B1	13.63	5.49	1.95	0.40
B2	13.05	4.55	1.61	0.35
C1	14.30	6.39	2.27	0.45
C2	13.27	6.35	2.25	0.48

TABLE -XXIX
STATISTICAL ANALYSIS OF FREE CARBONDIOXIDE

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	45.25	28.16	9.99	0.62
A2	68.50	43.09	15.28	0.63
B1	56.00	38.77	13.75	0.69
B2	70.00	38.52	13.66	0.55
C1	46.50	26.30	9.33	0.57
C2	64.75	25.28	8.96	0.39
SUMMER A1	49.38	14.69	5.21	0.30
A2	44.25	11.02	3.91	0.25
B1	52.00	16.00	5.67	0.31
B2	49.63	20.94	7.43	0.42
C1	58.25	29.47	10.45	0.51
C2	69.13	13.22	4.69	0.19
RAINY A1	66.75	36.22	12.84	0.54
A2	71.25	67.78	24.04	0.95
B1	63.50	18.43	6.54	0.29
B2	59.13	18.01	6.39	0.30
C1	67.13	33.51	11.88	0.50
C2	65.25	30.18	10.70	0.46

TABLE -XXX
STATISTICAL ANALYSIS OF BICARBONATE CONTENT

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	407.48	48.43	17.17	0.12
A2	469.13	113.54	40.26	0.24
B1	444.69	87.40	30.99	0.20
B2	512.46	91.23	32.35	0.18
C1	392.54	73.08	25.92	0.19
C2	448.93	65.98	23.40	0.15
SUMMER A1	489.22	118.38	41.98	0.24
A2	485.56	122.14	43.31	0.25
B1	534.97	126.30	44.79	0.24
B2	514.54	94.31	33.44	0.18
C1	509.10	107.65	38.17	0.21
C2	455.37	121.44	43.06	0.27
RAINY A1	342.03	121.42	43.06	0.35
A2	367.12	131.73	46.71	0.36
B1	279.98	119.33	42.32	0.43
B2	296.54	138.04	48.95	0.47
C1	324.89	155.85	55.27	0.48
C2	315.18	131.65	46.68	0.42

TABLE -XXXI
STATISTICAL ANALYSIS OF TOTAL ALKALINITY

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	334.00	39.70	14.08	0.12
A2	384.50	93.11	33.02	0.24
B1	364.50	71.64	25.41	0.20
B2	403.00	50.50	17.91	0.13
C1	317.38	65.96	23.39	0.21
C2	368.00	54.11	19.19	0.15
SUMMER A1	401.00	97.04	34.41	0.24
A2	398.00	100.11	35.50	0.25
B1	438.50	103.52	36.71	0.24
B2	421.75	77.31	27.41	0.18
C1	417.25	88.29	31.31	0.21
C2	373.25	99.54	35.30	0.27
RAINY A1	281.00	97.90	34.72	0.35
A2	303.75	107.56	38.14	0.35
B1	225.00	92.31	32.73	0.41
B2	243.63	112.04	39.73	0.46
C1	267.00	126.44	44.84	0.47
C2	259.00	106.46	37.75	0.41

TABLE -XXXII
STATISTICAL ANALYSIS OF CALCIUM CONTENT

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	92.63	11.44	4.06	0.12
A2	91.26	31.51	11.17	0.35
B1	95.78	10.26	3.64	0.11
B2	109.98	31.65	11.22	0.29
C1	103.77	23.75	8.42	0.23
C2	112.07	37.45	13.28	0.33
SUMMER A1	86.00	24.61	8.73	0.29
A2	47.20	23.30	8.26	0.49
B1	90.94	30.45	10.80	0.33
B2	49.51	20.30	7.20	0.41
C1	107.87	6.96	2.47	0.06
C2	78.20	19.58	6.94	0.25
RAINY A1	79.43	22.99	8.15	0.29
A2	62.02	23.02	8.16	0.37
B1	76.30	20.87	7.40	0.27
B2	42.55	13.18	4.67	0.31
C1	81.67	23.42	8.30	0.29
C2	53.39	20.17	7.15	0.38

TABLE -XXXIII
STATISTICAL ANALYSIS OF MAGNESIUM CONTENT

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	20.22	13.50	4.79	0.67
A2	22.55	16.40	5.82	0.73
B1	21.15	14.88	5.28	0.70
B2	24.51	20.88	7.40	0.85
C1	21.23	17.65	6.26	0.83
C2	25.60	21.35	7.57	0.83
SUMMER A1	13.19	9.21	3.27	0.70
A2	15.73	8.29	2.94	0.53
B1	14.72	11.09	3.93	0.75
B2	11.26	3.82	1.35	0.34
C1	13.97	13.31	4.72	0.95
C2	11.81	8.89	3.15	0.75
RAINY A1	9.71	7.39	2.62	0.76
A2	12.69	6.46	2.29	0.51
B1	5.71	2.17	0.77	0.38
B2	9.62	6.08	2.16	0.63
C1	10.58	9.00	3.19	0.85
C2	12.58	8.02	2.84	0.64

TABLE -XXXIV
STATISTICAL ANALYSIS OF TOTAL HARDNESS

SEAS./ST.	MEAN	S D	S E	VARIATION
WINTER A1	281.25	35.73	12.67	0.13
A2	285.00	57.53	20.40	0.20
B1	272.50	31.96	11.34	0.12
B2	329.00	61.77	21.90	0.19
C1	306.25	59.16	20.98	0.19
C2	335.00	84.42	29.94	0.25
SUMMER A1	254.25	54.45	19.31	0.21
A2	173.00	47.11	16.70	0.27
B1	270.25	62.16	22.04	0.23
B2	161.50	45.42	16.11	0.28
C1	307.25	8.54	3.03	0.03
C2	238.25	66.36	23.53	0.28
RAINY A1	275.75	97.90	34.72	0.36
A2	192.25	74.51	26.42	0.39
B1	224.50	82.97	29.42	0.37
B2	141.88	49.91	17.70	0.35
C1	233.13	87.21	30.93	0.37
C2	183.25	73.57	26.09	0.40

SECTION - 9

GENERAL SUMMARY

SECTION-9

SUMMARY

Reservoir are the fresh water bodies which take the first place in availability of water bodies for mankind if only judiciously used. If care is not taken these tend to become unavailable and is a waste of water resource, as mostly malpractices of mankind make them highly polluted. So far no work of any significance has been done on reservoir Ecology in Bundelkhand. Thus this work has been planned to study the Physico- chemical aspect and algal flora of this reservoir.

The Pani Ki Dharamshala Reservoir selected for study is situated in the heart of Jhansi city with dense population. It is surrounded by buildings and temples though separated with a constructed boundary. Often flowers and others waste materials of the temple are dumped in it. The area of Reservoir is 75 ft by 100 ft with a depth of 10 to 20 ft (approx) which has reduced due to accumulation of organic matter.

The water was earlier used for bathing and washing clothes but later its condition deteriorated due to heavy dumping and increasing growth of life forms. Due to increased Eutrophication, the hydroplanktons and vegetation increased. As the Reservoir was under such stressed condition, study was undertaken so that its hazardous nature concerning human health could be noticed as it may host various pathogenic organisms.

The present investigations were carried out from October 1999 to September 2000 Water samples were collected from three Sampling Stations or sites. These were A, B and C situated near the three temples around its

viscinity. Fortnightly samples were collected from two different levels at each Sampling Stations.

Monthly Variations in various Physico-chemical parameters, Phytoplanktons and Microbial population were investigated in the water samples. Datas were collected for – Colour, Temperature, pH, Conductivity, Chloride content, Dissolved Oxygen, BOD, Free Carbondioxide, Total Alkalinity, Carbonate/Bicarbonate, Calcium Content, Magnesium Content, Total Hardness, Phytoplanktons and Bacteriological variations with special reference to E. Coli, Streptococcus faecalis, Salmonella typhii and Vibrio cholerae.

Turbidity is caused by suspended matter. The clarity of the reservoir water varied from one Sampling Station to another. At Sampling Station A the water was usually clear and colourless with few suspended fragment and prticles. At Sampling Station B however yellow colouration was observed in June and turbidity was recorded in October, December and January with most turbid water in December 99. The water of Sampling Station C was usually turbid with high turbidity during October, November and December 99 and May and June 2000.

Usually it was noticed that the water at all sites was clear during Rainy months with few suspended particles.

The Water Temperature during the study period varied between 16 ^{0}C to 30^{0} C . Here again different results were observed at different sites due to their location and surroundings. At all Sampling Stations the temperature recorded was however low during January and February. Slight stratification was also observed as often difference in water temperature of surface water and water at depth was noticed though the variation was of 1-2 ^{0}C.

At Sampling Station A at upper surface the lowest temperature was 17^0C in January 2000 first fortnight and highest temperature was 29 ^0C in July 2000 first fortnight. The lower level water also showed least temperature in January first fortnight, values being 16^0C and highest temperature was recorded in July first fortnight – 27^0C.

At Sampling Station B the surface water temperature varied from 18^0C to 30^0C in the months of January (first fortnight) and July (first fortnight) respectively.

At Sampling Station C in surface water variation in temperature was observed from 17^0C (January first fortnight) to 31^0C (October 99 first fortnight) and the temperature of water at depth ranged from 15^0C (January second fortnight) to 30^0C (October 99 first fortnight)

Temperature affected the biochemical and biological reaction. In this reservoir higher temperature was usually recorded during winter season.

pH – During the study period its variation range was narrow usually ranging from 7 to 9.3. The pH of water at all Sampling Stations was towards alkaline side. It was higher during summer season at Sampling Stations A and B while in Rainy season at C. While lowest pH value was recorded in winter season at all sites. At A the pH of surface water ranged from 7.4 to 9.2 and at lower depth it ranged from 7.1 to 9.3.

At Sampling Station B the range of pH was 7.3 to 9.2 at both the levels. At Sampling Station C, pH varied from 7.1 to 9.2 in surface water and pH of water at depth was 7.0 to 9, pH showed correlation with Biocarbonate and Hardness.

Conductivity of the reservoir water was very low ranging from 0.4 to 0.8 mMho.For maximum part of the study period it was 0.8 mMho at all Sampling Staions. Lowest values were recorded in Dec 99. The conductivity

of two levels of water was nearly same and variation if at all was of o.1 mMho.

Chloride Content

The lowest Value recorded ranged from 3.99 mg/L (at B_2) to 14.4 mg/L (at A_1) and it was in the beginning of the study period that is in the first fortnight of October 99.

Overall during the study period lowest value of chloride content recorded was 3.99 mg/L (at B_2) and highest value was 163.45 mg/L at B_1 in December 99 first fortnight.

Generally it was found that the Chloride was more in upper level water than in lower level water. However from January 2000 to March 2000 and also in August 2000 the reverse was observed.

Average seasonal value was usually higher in summer season at A_2, B_1, B_2 and in winters at A_1, C_1, C_2.

At Sampling Station A the value in surface water ranged from 14.49 mg/L (October 99 first fortnight) to 138.96 mg/L (September 2000 second fortnight) and in lower level it ranged from 10.49 mg/L (October99) to 118.96 mg/L (December 99 second fortnight).

At Sampling Station B it ranged from 4.49 mg/L (October first fortnight) to 127.96 mg/L (September 2000 second fortnight) in surface waters. At Sampling Station C the values were comparatively higher and varied from 9.99 mg/L (October99) to 142.92 mg/L (December 99 second fortnight) in surface water and 7.49 mg/L (October 99) to 143.96 mg/L (June 2000 second fortnight) in lower level water.

No particular time period could be determined for highest value of Chloride as it varied from one Sampling Station to another. The variations are also the results of human interference and waste disposal hence it can also be

said that high amount of Chloride gives a possible indication of some source of sewage drains opening in to the reservoir.

Dissolved Oxygen As per the datas recorded, the value of Dissolved Oxygen (D.O) in the reservoir ranged from 3.02 mg/L (June2000) to 40.32 mg/L (October99). The highest values of D.O were obserbed in October 99 at all Sampling Stations and least in June 2000. It was usually more in surface waters than in lower level water except in April and June 2000 first fortnight. The highest values were generally recorded during winter season and lowest during summer season . At Sampling Station A highest values were recorded in October first fortnight in upper and lower level water, values being 24.19 and 22.18 mg/L respectively. Low values in both the levels were observed in June 2000 4.03 mg/L in surface water and 5.04 mg/L in lower level water. Nearly same trend was observed at Sampling Station B, highest value recorded in October 99, second fortnight the value being 40.32 mg/L and 36.29 mg/L in upper and lower level water respectively.

At Sampling Station C the values in surface waters ranged from 3.02 mg/L (June 2000 first fortnight) to 34.27 mg/L (October 99second fortnight) and in lower level it ranged from 6.05mg/L (June 2000 first fortnight) to 31.29 mg/L (October 99 second fortnight).

The Dissolved Oxygen is an important factor for water quality assessment. The lower value in warm months is due to decomposition of organic matter.

BOD : From the analytic data it could be observed that BOD showed great variation, the values ranged from 3.92 mg/L to 29.5 mg/L. Usually higher values of BOD were observed in summer season and lower values in winter season. The surface water usually recorded higher BOD values as compared to the lower level water. At all sites minimum values were recorded

in January 2000 and maximum values in April 2000 except in water sample A_1 where it was observed in March 2000.

At Sampling Station A the BOD values ranged from 4.18 mg/L (January 2000 first fortnight) to 23.2 mg/L (April 2000 first fortnight) in surface water and from 4.10 mg/L (December 99 second fortnight to 21.32 mg/L (April second fortnight) in lower level water.

At Sampling Station B in surface water minimum value recorded was 4.01 mg/L (January 2000 first fortnight) and maximum value was 19.38 mg/L (April first fortnight). In lower level water, the minimum value recorded was 3.92 mg/L (January 2000 first fortnight) to maximum of 17.22 mg/L in April 2000 first fortnight.

At Sampling Station C comparatively higher values were obtained in upper surface it ranged from 5.10 mg/L (January 2000 first fortnight) to 29.5 mg/L (April first fortnight). As BOD showed positive correlation with microbial population hence high value in summer is attributed to biological activity.

Free Carbondioxide concentration was usually found to be more at lower depth than in surface water, reverse trend was observed from May 2000 to September 2000. The first peak in Free Carbondioxide values was observed in December 99 thereafter no fixed trend of increase or decrease in Carbondioxide concentration was decrease in Carbondioxide concentration was observed. Usually it was higher in rainy season except in B2 and C2. The values usually ranged from 20 mg/L to 242 mg/L.

At Sampling Station A in upper surface lowest value of Free Carbondioxide was 20 mg/L observed in four months (October 99 first fortnight, November 99 second fortnight, January 2000 first fortnight and February 2000 first fortnight) and highest value of 142 mg/L was observed in

September 2000 second fortnight. In lower level water least value was 30 mg/L (In November 99 second fortnight, January 2000 first fortnight, March second fortnight and June first fortnight) and highest value was recorded in September 99 second fortnight-242 mg/L.

At Sampling Station B least value in upper surface was 20mg/L (October 99 first fort night), November 99 second fortnight and March 2000 second fortnight and highest value was 12.6 mg/L in December 99 second fortnight. In the lower level water of B value ranged from 30mg/L (October 99 first fortnight, November 99 second fortnight) to 136 mg/L (December 99 first fortnight).

At Sampling Station C in surface water concentration of Free Carbondioxide was between 30 mg/L and 138 mg/L (August 2000 second fortnight); in lower level the value ranged between 40 mg/L to 114 mg/L. (August 2000 second fortnight). Scientists have reported that Free Carbondioxide was generally high in polluted waters and aquatic plants also bring about change in the amount of carbondioxide in water.

Bicarbonate content – The reservoir water gave positive results for Bicarbonate alkalinity and hydroxide and carbondioxide were absent. High values were recorded in summers and this could be due to mixing of effluents. The first peak in Bicarbonate content values was observed in December 99 thereafter decline in the values was observed till April 2000. Usually higher values were observed in two summer months –April and May 2000. From May to the end of July 2000 a gradual decline was observed. The average seasonal data in Table IX B reveal that highest values of Bicarbonate content was observed in summer season (attributed to evaporation) followed by winter season. Least values were observed in Rainy season. Least values

usually ranged from 170.8 mg/L (in B_2 in July 2000 second fortnight) to 732 mg/L (B1 in May first fortnight).

At Sampling Station A upper level water the values ranged from 280.6 mg/L to 634.4 mg/L and in lower level water it ranged from 258.64 mg/L to 732 mg/L. At Sampling Station B the lowest value of Bicarbonate content in upper surface was 185.4 mg/L and highest value was 732 mg/L. In lower level water (B2) it ranged from 170.8 mg/L to 690.52 mg/L. At Sampling Station C the values in upper level ranged from 229.36 mg/L to 629.52 mg/L and in lower level water it ranged from 234.24 mg/L to 622.2 mg/L.

Total alkalinity is based on presence of Bicarbonates. Its higher value indicates towards pollution. Two peaks of Alkalinity values were observed, first in December 99 and second in April 2000 or May 2000. As per the data recorded in Table XB the average values were observed to be high in summer season at all Sampling Stations. The values ranged from 152 mg/L to 600 mg/L.

At Sampling Station A the values in surface water ranged from 230 mg/L (October 99 first fortnight) to 520 mg/L (April 2000 first fortnight) and for most of the sampling period was less than that in the lower level water. The total alkalinity of lower level water ranged from 212 mg/L (October 99 first fortnight) to 600 mg/L (April first fortnight). At Sampling Station B the alkalinity in surface water varied between 152 mg/L (July 2000 second fortnight) to 600 mg/L (May 2000 Ist fortnight) and in lower level water it ranged from 140 mg/L (July 2000 second fortnight) to 522 mg/L (February 2000 second fortnight). At Sampling Station C the value ranged from 188 mg/L (July second fortnight) to 516 mg/L (May 2000 first fortnight) in surface water and 192 mg/L (July 2000 second fortnight) to 510 mg/L (April

first fortnight) in lower level water. It showed positives correlation with pH to some extent.

Calcium Content variation showed different trends at different Sampling Stations, infact no definite trend of comparative values of two levels was observed. In samples from Sampling Station A, B and C usually Calcium content was more in the suface water except for few months in between when reverse was observed. Average seasonal value showed that it was usually higher in winter season except at C_1 (upper level water at Sampling Station C) where it was higher in summer season. The Calcium content in the Reservoir water ranged from 21.03 mg/L (at B_2 in April 2000 first fortnight) to highest value of 158.96 mg/L (at C_1 in December 99 second fortnight).

At Sampling Station A in upper surface water values ranged between 35.52 mg/L (May first fortnight) to 129.52 mg/L (June first fortnight) and in lower level water (A_2) it varied from 25.23 mg/L (April second fort) to 147.18 mg/L (October first fortnight). At Sampling Station B the values were higher. In surface water (B1) calcium content varied from 42.05 mg/L (April first fortnight) to 153.07 mg/L (May first fortnight) and in lower level water it ranged 21.03 mg/L (April Ist fort) to 147.18 mg/L (January first fort). At Sampling Station C in upper level water calcium content varied from 68.97 mg/L (July second fortnight) to 158.96 mg/L (December 99 second fortnight) and in lower level water from 27.03 mg/L (September 2000 second fortnight) to 154.75 mg/L.

Total Hardness – The observation recorded in Table XII A reveal that mostly the surface water was hard for maximum period of study except in October 99 and December 99 (at A), October 99 to December 99, January

2000 & February 2000 at B and November 99, December 99, January 2000 at C when reverse was observed .

At site A and B both levels and at C in lower level water the average seasonal value was higher in winter season and mostly least value was observed in rainy season.

At Sampling Station A in surface water total hardness varied from 152 mg/L (May 2000 first fort.) to 358 mg/L (June second fortnight) in lower water from 122 mg/L (May first fort) to 384 mg/L (October 99 first fort). At Sampling Station B in surface water it varied from 194mg/L (July second fortnight) to 414 mg/L (May 2000 first fort) and in lower level water it was less than the upper level water 102 mg/L (April first fort) to 402 mg/L (December first fort). At Sampling Station C it ranged between 198 mg/L and 432 mg/L in surface water and from 146 mg/L to 438 mg/L.

Magnesium content variation did not follow any definite pattern. Usually maximum amount was recorded in winter months. The Magnesium content was comparatively low in the later half of study period. At Sampling Station A in surface water it ranged between 3.32 mg/L (June second fort) to 47.83 mg/L (November 99 first fortnight) and in lower level between 4.05 mg/L (October 99 first fort) to 55.49 mg/L. (December 99 first fortnight). At Sampling Station B the values were nearly within same range, in surface water it's range of variation was from 3.42 mg/L (August second fortnight) to 51.80 mg/L (December 99 first fort) and lower level. 3.46 mg/L (December 99 second fort to maximum of 65.05 mg/L (December 99 first fortnight). At Sampling Station C the maximum were recorded in December 99-57.62 mg/L in upper level and 68.14 mg/L in lower level water. The minimum value at this Sampling Station was recorded in June second fortnight showing very low values 0.49 mg/L and 1.70 mg/L in C1 and C2 samples respectively.

The study of Diurnal variation in physico-chemical parameters was carried out in March (3^{rd} march) for 24 hours at 4 hrs interval. The samples were collected from the same Sampling Stations which were decide for fortnightly study – A, B, and C similar methods of analysis were followed as those during fortnightly study. The datas of Duirnal variation in different parameters were recorded in Table XIV.

During the early hours of the day i.e at 4.30 am the water temperature of surface water was nearly same as that of atmospheric temperature but the water at depth had lower temperature. At 8.30 am there was rise in temperature of water at both the levels and till 4.30 pm the surface water temperature was higher than that at depth. During midnight reversal was observed i.e water temperature of both the levels was higher than the atmospheric temperature. In general water temperature ranged between 15^0C to 22^0 C, the trend of rise and fall for entire study area varied from station to station.

The values of <u>Conductivity</u> during the day remained almost same at all the Sampling Station even at different depths, it ranged between 0.7 to 0.8 mMhos.

The <u>pH</u> did not show much variation during the diurnal study. The values ranged from 7.3 to 8.2 pH showing alkaline nature of water. Slight variations were observed during day time but during late hours it did not vary much. No definate trend could be discerned. During midnight however lower pH was recorded in water at depth.

The variation in values of Chloride content did not show any fixed pattern.At Sampling Station A , the Chloride content increased from 4.30 am to 12.30 noon from 83.47mg/L to 116.96 mg/L in surface water and from 73.98 mg/L to 156.45 mg/L in lower level water. From 12.30 noon to 8.30 pm

the Chloride content gradually decreased in water at both the levels. At Sampling Station B the value of Chloride content fluctuated at each sampling period, the values ranged from 56.48 mg/L to 116.46 mg/L in surface water and from 102.98 to 156.45 mg/L in water at depth. It was generally more in lower level than in surface water except at 4.30 am. At Sampling Station C the variation in Chloride content followed a different trend at different levels. In surface water the value increased from 4.30 am to 4.30 pm while in water at depth the values showed decrease during the same period. In surface water it varied from 94.47 to 127.46 mg/L and in lower level it varied from 72.48 to 152.93 mg/L.

The values of Dissolved Oxygen showed fluctuations in surface water and lower level water and from one Sampling Station to other. Dissolved Oxygen ranged from 1.81 mg/L to 9.48 mg/L.

At Sampling Station A it was usually higher in surface water than in lower level water. In surface water the Dissolved Oxygen content ranged from 2.82 mg/L to 7.86 mg/L and in lower level waterfrom 1.81 mg/L to 6.85 mg/L. The lower level water showed more changes during daily periodicity as compaired to surface water. At Sampling Station B at three sampling stages – 4.30 am, 12.30 noon and 4.30 pm the value of Dissolved Oxygen was more in surface water than in lower level water and at 8.30 am, 8.30 pm, and 12.30 midnight the rivers was observed at surface level the values ranged from 2.02 mg/L to 9.48 mg/L and in lower level water it varied from 2.22 mg/L to 6.25 mg/L.

At Sampling Station C the amount of Dissolved Oxygen in surface water was usually more than or equal to that found in lower level water. The values of Dissolved Oxygen ranged from 2.22 mg/L to 6.05 mg/L in upper level water at C and from 1.61 mg/L to 6.23 mg/L in lower level water. Thus

in diurnal variation it could be observed that variation in Dissolved Oxygen did not follow any fixed pattern of increase and decrease in values at any time period.

BOD of water during Diel variation showed almost the similar trend at two Sampling Stations – A and C while at site B slight difference was noted.

At 'A' and 'c' BOD values were found to be more in surface water as compaired to lower level water. At sampling station B at four sampling stages similar pattern was observed while reverse pattern was recorded at the remaining sampling stages.

At sampling station A BOD value of surface water was always higher than the lower level water. the value increased from 4.30am to 4.30pm and then it gradually decreased till midnight, minimum value observed at 4.30 am and max at 4.30 pm, values being 8.48 mg/L to 13.45 mg/L in surface waters and from 7.02 to 11.86 mg/L in lower level water.

At Sampling Station B the surface water showed minimum value at 4.30 am – 7.88 mg/L and increased till 4.30 pm to maximum of 11.84 mg/L then there was decrease in value till midnight. The undersurface water showed different pattern after 12.30 noon. In under surface water the values ranged from 8.92 mg/L at 4.30 am to max. of 9.44 mg/L at 12.30 noon.

At Sampling Station C the trend was similar to that observed at A in the context that more values were recorded in surface water than at lower level. The pattern of increase or decrease was almost zigzag.

The BOD ranged from 9.88 mg/L (at 4.30 am) to max. of 13.12 (at 4.30 pm) in surface waters and from 7.12 (at 4.30 am) to 10.42 mg/L (at 8.30 am) in lower level water.

Diel variations in Free Carbondioxide at two levels did not show a fixed trend till 12.30 noon. From 4.30 pm to 12.30 midnight the Free

Carbondioxide showed a definite trend with context to two levels i.e it was usually found to be more in lower level water at all Sampling Stations. The value of Free Carbondioxide was usually higher from 4.30 pm to 12.30 midnight as compaired to early hours of the day.

At Sampling Station 'A' the value of CO_2 in surface water varied from 16 mg/L (at 4.30 pm) to 180 mg/L (at 12.30 midnight), in lower level water from 14 mg/L (12.30 noon) to 364 mg/L (at 12.30 midnight). At Sampling Stations 'B' from 4.30 am to 4.30 pm no fixed trend could be observed thereafter from 8.30 pm to 12.30 midnight the amount of Free Carbondioxide increased. At both the levels (B1 and B2) peak values were recorded at 12.30 midnight. In surface water values ranged from 16 mg/L (at 8.30 am) to 186 mg/L (at 12.30 midnight) and at lower level from 12 mg/L to 232 mg/L. At Sampling Stations 'C' the trend of variation in value of Free Carbondioxide was nearly same as that observed at other Sampling Stations. Till 4.30 pm no fixed trend with context to two levels could be discerned however at 8.30 pm and at 12.30 midnight Free Carbondioxide was more in lower level water as compaired to that in surface water, peak values in water at both the levels were recorded at 12.30 midnight. In surface water the value ranged from 16 mg/L (at 4.30 pm) to 204 mg/L (at 12.30 midnight) and in lower level it varied between 14 mg/L (8.30 am) and 282 mg/L (at 12.30 midnight).

Bicarbonate Content of pond under study generally showed higher values in water at depth as compaired to that in surface water during diurnal studies.

At Sampling Station 'A' in surface water minimum value was recorded at 4.30 am-170.44 mg/L and maximum value at 12.30 midnight – 236.32 mg/L. The value had decreased at 4.30 pm. The lower level water showed

more fluctuations and the value varied between 180.56 mg/L (at 8.30 am) and 192.76 mg/L (at 12.30 noon).

At Sampling Station B similar trend was observed i.e higher values in lower level water than that found in surface water. The surface water at B had a minimum value at 4.30 am –170.88 mg/L and maximum value at 12.30 midnight –207.24 mg/L. In lower level water the values ranged from 173.24 mg/L (at 4.30 am) to 193.4 mg/L (at 12.30 midnight).

At Sampling Station C the Bicarbonate Content was more in lower level water. The general trend of increase and decrease in value was same as that found at other Sampling Stations i.e rise from 4.30 am to 12.30 noon then decline at 4.30 pm and thereafter gradual rise till 12.30 midnight. The values ranged from 180.88 mg/L (at 4.30 am) to 198.88 (at 4.30 pm) in surface water and from 183.72 mg/L (at 4.30 am) to 200.08 mg/L (at 12.30 noon).

The diel variations in value of Total Alkalinity followed the same trend as that observed in Bicarbonate Content. From 4.30 am to 12.30 noon it was more in lower level water at all Sampling Stations, at 4.30 pm reversal was observed at B and C.

At Sampling Stations A generally Total Alkalinity was more in lower level water except at 12.30 midnight. The values ranged from 139.70 mg/L (at 4.30am) to 193.70 mg/L (at 12.30 midnight) in surface water and from 148 mg/L (at 8.30 am) to 158 mg/L (at 12.30 noon) in lower level water. At Sampling Station B usually the Total Alkalinity was more in lower level water except at two sampling stages-4.30 pm and 12.30 midnight. In surface water it increased from 4.30 am to 4.30 pm then declined at 8.30 pm and reached maximum at 12.30 midnight (207.24 mg/L). In lower level water the Bicarbonate Content varied from 173.24 mg/L (4.30 am) to 193.40 mg/L (at 12.30 midnight). At Sampling Stations C the general trend of increase and

decrease in value was same as that found at other Sampling Stations. In surface water minimum value was recorded at 4.30 am-180.88 mg/L and maximum at 4.30 pm-198.88 mg/L and in lower level water minimum value was recorded at the same time & was 183.72 mg/L to max. of 200.08 mg/L at 12.30 noon.

The diel variations in Total Alkalinity also followed the same trend as that observed in Bicarbonate Content. From 4.30 am to 12.30 noon it was more in lower level water at all Sampling Stations; at 4.30 pm reversal was observed at stations 'B' and 'C'.

At Sampling Stations A generally Total Alkalinity was more in lower level water except at 12.30 midnight. The values ranged from 139.70 mg/L (at 4.30 am) to 193.70 mg/L (at 12.30 midnight) in surface water and from 148 mg/L (at 8.30 am) to 158 mg/L (at 12.30 noon) in lower level water.

At Sampling Stations B usually the Total Alkalinity was more in lower level water except at two sampling stages-4.30 pm and 12.30 midnight. The values in upper level water varied between 140.06 mg/L (at 4.30 am) and 169.87mg/L (at 12.30 midnight). The undersurface water showed a different trend as a zigzag pattern of increase and decrease in value was observed. The values ranged from 142 mg/L (at 4.30 am) to 158.52 mg/L (at 12.30 midnight). At Sampling Station C – variations in values of Total Alkalinity showed similar trend as that found at Sampling Station B with reference to values at two levels. Minimum value was recorded at 4.30 am –148.26 mg/L and maximum of 163.02 mg/L (at 12.30 noon).

From Table XIV it could be observed that there was positive correlation between Calcium Content & Bicarbonate Content. However minimum amount of calcium content was recorded at 12.30 noon and maximum was obtained at 8.30 pm.

At Sampling Station A the value ranged from 39.44 mg/L (at 12.30 noon) to 135.55 mg/L (at 12.30 midnight) in surface water and 41.87 mg/L (at 12.30 noon) to 133.73 mg/L (at 4.30 pm) in lower level water. At Sampling Station 'B' the variations in Calcium Content showed almost similar trend as found at A. In surface water it varied between 42.80 mg/L (12.30 noon) to 106.81 mg/L (at 8.30 pm). In lower level the values ranged from 55.56 mg/L (at 12.30 noon) to 138.86 mg/L (at 4.30 am).

At Sampling Station C, decline in value could be observed till 12.30 noon thereafter it increased and ultimately decreased again. In surface water Calcium Content varied from 25.14 mg/L (at 12.30 noon) to 110.18 mg/L (at 4.30 pm) and in lower level water it varied from 45.23 mg/L (at 12.30 noon) to 156.44 mg/L (at 8.30 pm).

The Total Hardness values were higher as compaired to Calcium Content and trend of variation was similar as that of Calcium Content.

At Sampling Station A the values ranged from 152 mg/L (at 12.30 noon) to 368 mg/L (at 4.30 pm) in surface water and from 156 mg/L (at 12.30 noon) to 378 mg/L (at 4.30 pm). At Sampling Station B the trend of variations in two levels was different from that observed at 'A', at some sampling stages it was more in surface water and reverse was found at the remaining half sampling stages. For rise and fall in value the trend was almost similar. The values in surface water varied from 158mg/L to 296 mg/L whereas it was higher in lower level from 174 mg/L to 370 mg/L. At Sampling Station C, the Total Hardness was usually higher in lower level water (C_2). The least value in surface water was recorded at 12.30 noon-104 mg/L and highest value was obtained at 4.30 pm (310 mg/L). In lower level water it ranged between 166 mg/L (at 12.30 noon) and 406 mg/L (at 8.30 pm).

The Magnesium Content recorded during the day was low. Mostly the values in lower level water were higher as compaired to that in surface water.

At Sampling Station A in surface water the value varied between 6.27 mg/L (at 4.30 am) to 13.96 mg/L (at 4.30 pm) and between 7 mg/L (at 4.30 am) to 12.9 mg/L (at 12.30 noon).

At Sampling Stations B the two levels showed a different pattern of rise and fall of Magnesium Content. The values in surface water ranged from 7.1 mg/L (8.30 pm) to 12.4 mg/L (at 12.30 noon). In lower level it varied from 5.7 mg/L to 13.2 mg/L.

At Sampling Station C no particular relationship could be derived between the Magnesium Content of surface and lower level water, similarly no fixed trend in rise and fall in values could be observed. In surface water the minimum value was 7.17 mg/L (at 12.30 midnight) and maximum was 11mg/L (at 4.30 am). In lower level the values ranged between 3.75 (at 8.30 pm) to 12.8 (at 12.30 noon).

Phytoplanktons.

In the present study of **'Pani Ki Dharamshala'** reservoir, water samples were collected from different Sampling Stations and mixed to form composite sample. Quantitative and Qualitative studies were carried out monthly to identify the Phytoplanktons and derive the nature of reservoir. The monthly observations were recorded in Table XV A and Table XVI.

The planktons reduced in number gradually as by the end of the study period the reservoir had a dense coverage of macrophytes.

During the present study 18 genera of Phytoplanktons, belonging to 4 different groups were identified. The different Phytoplanktonic groups recorded were as follows in ascending order of number of genera:-

Euglenophyceae<Bacillariophyceae<Cyanophyceae<Chlorophyceae

8 genera identified belonged to Chlorophyceae, 6 genera to Cyanophyceae, 3 genera to Bacillariophyceae and Euglenophyceae was represented only by 1 genera. Though the number of genera belonging to Chlorophyceae were more than those of Cyanophyceae, the total count of cells/L of Cyanophyceae members were usually found to be higher than Chlorophyceae every sampling month.

The members of group Chlorophyceae, Cyanophyceae and Bacillariophyceae were present throughout the study period. Euglenophyceae was present mostly during winter season and generally could not be observed during summer months.

Seasonal variations recorded in Table XV B reveal that total population of Chlorophyceae, Cyanophyceae and Euglenophyceae was higher in winter season as compaired to the count observed in others seasons; Bacillariophyceae however recorded highest count in summer season. Infact Total planktonic population was highest in winters.

Total Count of different groups throughout the study period show that Cyanophycean population was highest – 198 x 10^3 cells /L followed by Chlorophyceae – 115 x 10^3 cells/L.

Monthly observations recorded in table XV A show that Chlorophyceae had the highest count in October 99 – 23 x 10^3 cells/L; Cyanophycean count also was highest in October 99 – 25 x 10^3 cells/L. The Bacillariophyceae showed its highest count in March 2000-13 x 10^3 cells/L. Highest population of Euglenophyceae was recorded in November 99- 5 x 10^3 cells/L.

The Chlorophyceaen genera identified during the study period were- Ankistrodesmus, Chlamydomanas, Chlorella, Cosmaruim, Scenedesmus,

Spirogyra, Pediastrum and Closterium of these Spirogyra and Pediastrum were more frequently present during the study.

Amongst Cyanophyceae Oscillatoria and Microcystis were present throught the year. The other genera identified during the present study were Aphanocapsa, Chrococcus, Merismopedia, Oscillatoria, Phormedium, Microcystis. Highest population was of Oscillatoria followed by Merismopedia.

The Euglenophyceae was represented was only one genera-Euglena.

The 3 genera belonging to Bacillariophyceae were – Pinnularia, Navicula and Synedra, Navicula could be observed throughout the study period and was in high number than the other two genera.

The abundance of Chlorophyceae and Cyanophyceae reveal that the reservoir water was highly polluted including sewage contamination and indicate towards Eutrophy.

Bacteriological studies included the –

(a) Standard plate count- by this total number of viable organisms present in the water were counted.

(b) M.P.N Count – This method was applied to estimate the contamination level of the water.

(c) Detection of presence of certain Pathogenic bacteria, like-Salmonella typhii; Streptococcus faecali's and Vibrio cholerae.

Standard plate count is useful in determining the quality of water. It gives an indication of type of organic matter present in the water as the bacteria growing at 37^0C are generally associated with organic matter of human or animal origin, whereas those growing at lower temperature are mainly saprophytes which enter the water from ranged from 17×10^7 to $152 \times$

10^7 colonies per ml. General trend of variation was usually same at all Sampling Stations i.e low being during winter season (lowest value usually observed in December 99). The value increased in summer season (highest values were obtained in May/June). At Sampling Station A the minimum viable count was recorded in December 99- 18 x 10^7 and maximum was recorded in May 2000 Second fortnight-124 x 10^7. At Sampling Station B the bacterial count recorded was usually higher than observed at the other two sites. The values ranged between 24 x 10^7 (Jan 2000) and 152 x 10^7 (June 2000 first fortnight). At Sampling Station C the count ranged between 17 x 10^7 (Dec 99) to 100 x 10^7 (June 2000).

Thus it can be said that water at Site B is more contaminated than the other two sites.

To indicate the degree of sewage contamination the group of bacteria known as 'Coliforms' were detected. Infect Coliform Bacilli are reliable indicators of faecal pollution. This quantitative analysis included the MPN count. The result obtained are tabulated in table XX. From the table it could be observed that the variations in MPN count ranged between 64 to 2400 organisms per 100 ml of water. Lowest count was recorded in December 99 (second fortnight) at all Sampling Stations- least count at Sampling Station 'A' being 75 cells/100 ml of water, at Sampling Station 'B' it was 93 cells/100 ml. At Sampling Station 'C' it was recorded 64 cells/100 ml. Higher counts usually recorded in summer season. The result reveal that the count at Sampling Station B was usually higher than at the other two sites. This again indicates that water at samp.st. B is highly contaminated with sewage.

After conducting the Confirmed Test the result were recorded in Table XXI. From this Table it was evident that % occurance of E.Coli was comparatively high at Sampling Station B than observed at A and C. The

population of E.Coli according to their percent occurance was found to more during summer and rainy season than during winter season. At Sampling Station A the least % occurance of E.Coli was 15% (in December 99 first fortnight) and highest was 71.7% during July 2000 second fortnight. At Sampling Station B the highest percent occurance was 79.6% (June first fortnight) and lowest was in December 99 (first fortnight) 19.2%.

The Sampling Station C the least percent occurance was observed in December 99 - 9% and highest during September 2000 (first fortnight) 67.7%.

The increase in summer can be explained due to rise in temperature. During rainy season due to dilution of water the population was lower than that observed during summers, however it was higher than that recorded in winters. Occasional rise during rainy season can also be due to surface washing besides sewage contamination.

Specific tests were conducted to check the presence of 3 common pathogenic bacteria.-S.faecalis, Salmonella Typhi & Vibrio Cholerae. Their presence could not be ruled out due to the location and condition of the reservoir, as there is dumping of waste matter from households, temples and hospital as well as enterance of sewage through drainage systems.

Streptococcus faecalis was usually present throughout the study period at A and B in all 3 seasons, more frequently in summer season. At site C it could be deleted only during Summer season that too its occurance was rare. Salmonella Typhii could be rarely detected only at A and B Sampling Stations, only during summer season. Rare occurance of Vibrio Cholerae could be noted at Sampling Station A and C that too only during summer season.

SECTION - 10

BIBLIOGRAPHY

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